The Engineer.

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JANUARY 6, 1939—VOL. CLXVII

THE ENGINEER

A Seven-Day Journal

New Year Honours

IN the official list of New Year Honours bestowed by the King, the following names appear:—Dr. John Donald Pollock, chairman of Metal Industries, Ltd., and Sir William Peter Rylands, chairman of Rylands Brothers, Ltd., are made Baronets. Knighthoods are conferred upon Mr. William Chamberlain, Chairman of Traffic Commissioners, North-Western Area; Mr. Edward James George, general manager of the Consett Iron Company, Ltd.; Dr. Stephen Joseph Pigott, managing director of John Brown and Co., Ltd.; Mr. Harry S. E. Vanderpant, Chairman London and Home Counties Traffic Advisory Committee, and Mr. John Ballingall Forbes Watson, Director, National Confederation of Employers' Organisations. Admiral of the Fleet Baron Alfred Ernle Chatfield and Sir James Jeans, F.R.S., receive the Order of Merit. The order of C.B. is conferred upon Engineer Rear-Admiral Thomas Herbert Warde, and Mr. William George Hynard, Director of Sea Transport, Mercantile Marine Department, Board of Trade. In the India Office List, Lieut.-Colonel Haig, Chief Engineer, Public Works Department, United Provinces, and Lieut.-Colonel Platts, Superintending Engineer, Electricity Department, Madras, become C.I.E. In the Order of the British Empire, Major Henry George Howard, Chief Engineer for Electricity, Madras, receives a knighthood, as does the Hon. George Louis Goudie, Commissioner for Public Works, the State of Victoria, and Mr. Richard McNeal Henderson, M. Inst. C.E., M. I. Mech. E., Director of Public Works, Hong Kong. Sir John Reith, M. I. Mech. E., receives the G.C.V.O. in the Royal Victorian Order. In the Order of St. Michael and St. George, Baron Malcolm Hailey, Director, African Research Survey, becomes G.C.M.G., and Mr. Thomas St. Quintin Hill, Comptroller-General of the Department of Overseas Trade, becomes K.C.M.G. Among other honours we may appropriately refer to the G.B.E. which has been conferred upon Sir Frank Smith. The C.B.E. is awarded to Mr. Westgarth Forster Brown, M. Inst. C.E., M. Inst. M.E., Chief Minerals Adviser to the Commissioners of Crown Lands; Mr. Robert Crichton, chairman of the West Cumberland Development Company; Mr. George McLeod Paterson, N. Inst. N.A., principal naval architect to the Cunard White Star Company; Mr. Owen Glynne Roberts, secretary of the London, Midland and Scottish Railway Company, on the occasion of the centenary of the railway; Mr. Donald McLean Skiffington, shipyard director of John Brown and Co., Ltd., and Mr. Frederick Charles Starling, Assistant Secretary and Director of the Petroleum Department, the Mines Department.

Co-Operative Profit-Sharing

FORTY-THREE co-operative productive societies associated with the Co-operative Productive Federation issued through the Federation last week a statement of their financial position at the end of 1937. These societies had a combined pay-roll of 8207 employees and paid out £922,238 in wages during the twelve months. The sales totalled £3,035,943, providing a net surplus of £143,027, out of which allocations were made to capital amounting to £6185, £37,046 to labour, and £56,761 to their customers, while £5325 was granted to educational and charitable organisations. Of the four societies included in the metal-working group, the Walsall Locks and Cart Gear, Ltd., had at the end of 1937 assets totalling £55,758, the 414 employees receiving an aggregate of £47,717 in wages. Compared with the preceding year, its sales increased by nearly 25 per cent., amounting to £104,349, while its surplus rose from £2771 in 1936 to £5103. The shareholders received a 10 per cent. bonus, giving an allocation of £117, and a total of £4000 distributed among the workers provided an addition of 2s. in the £ on wages. Educational and charitable grants totalled £170. Only one other society in this group, the Chesham Builders, Ltd., was able to make a distribution of surplus. With 36 employees and a wages bill of £6060, it had a turnover of £12,642 (slightly less than in 1936), and made a surplus of £413. Capital received £26, or 2½ per cent. on shareholding, and labour £228, or 1s. in the £ on wages. The Leicester Carriage Builders, Ltd., employ 30 workers and paid £5107 in wages during the year. Its sales amounted to £14,121 and its surplus £384. The remaining society in this group is the East London Toy Factory, Ltd., which with 31 employees and paying £2232 in wages, did business to the extent of £6805, any surplus which it made being placed, presumably, to the credit of its previous deficiency of £836. The Alcester Needleworkers, Ltd., which has been included in this review in previous years, has been reorganised as the Alcester Productive Society, Ltd., and is now mainly concerned in the manufacture of clothing, the production of needles being a minor part of its business. This present summary serves to complete our account of the progress of profit-sharing and co-partnership during 1937 in the engineering and metal trades, and may be regarded as an addendum to the Journal note given in our issue of July 22nd of last year.

Retirement of Sir Charles Bressey

WITH the end of the year Sir Charles Herbert Bressey retired from the office of Engineer-in-Charge of the Highway Development Survey at the Ministry of Transport, a position which he held with distinction since his appointment in 1934. Sir Charles was educated principally in France and Germany, and subsequently joined his father in practice as a surveyor in the City of London, gaining experience in engineering and advisory work in connection with local authorities and various industrial undertakings. During the war he served as Lieut.-Colonel R.E. on the Western Front under General Sir Henry Maybury, Director of Roads, and was mentioned in despatches. He spent much of his time handling negotiations with regard to road engineering matters with the French and Belgian staffs, and subsequently became a member of the Inter-Allied Commission in charge of Rhine Province Communications. In 1919 he was invited to join the staff of the then newly formed Ministry of Transport and was appointed Divisional Road Engineer (London). At the Ministry he served under his old chief, Sir Henry Maybury, who had been appointed Director-General of Roads. He succeeded to the post of Chief Engineer in 1921, and occupied that position until in 1928 when he succeeded Sir Henry Maybury and was appointed Principal Technical Officer. In 1935 Sir Charles, who had received his knighthood following the C.B.E. in 1924 and the C.B. in 1930, became Engineer-in-Charge of the Highway Development Survey of Greater London, and his report was published in 1938. Alongside his official duties he yet found time for other work, and was President of the Surveyors' Institution and the Junior Institution of Engineers. He is an honorary member of the Institution of Royal Engineers and the Town Planning Institute and a member of the Permanent International Commission of Road Congresses. In 1934 he was British Government delegate to the Road Congress held in Berlin and Munich, and had an opportunity of studying German road development. His retirement at the comparatively early age of sixty-five will, we may express the hope, enable him to enjoy many years of happy and useful activity.

A Netherlands Naval Order

THE Royal Netherlands Naval Authorities have decided to construct twenty motor torpedo boats of a new design, prepared by Mr. Hubert Scott-Paine, of the British Power Boat Company, Ltd., of Hythe, Southampton. The first of the new boats is to be built by the British Power Boat Company at Hythe, and the subsequent boats will be constructed by the N.V. Gusto firm at Schiedam, near Rotterdam, under a building licence which has been arranged with the British Power Boat Company, Ltd. The design is entirely new and the type boat has recently undergone preliminary trials which have been carried out by the Netherlands Naval Authorities. The trial results were, we are informed, most satisfactory, and during the tests such factors as speed, manœuvrability, seaworthiness, and silence were tried out and carefully observed. The boats have a length of about 70ft. and the displacement is approximately 32 tons. The speed has not been disclosed, but we are given to understand that it is higher than that which has already been obtained with previous naval vessels of a similar type. The armament, which has been specially arranged to suit the requirements of the Netherlands Government, will include four 18in. torpedo tubes and two power-operated anti-aircraft guns, together with depth charges and smoke screen apparatus. In the event of 20in. torpedo tubes being specified, two such tubes can be incorporated in the design. The propelling machinery will consist of three 1000 S.H.P. Rolls-Royce-Power "Merlin" marine type engines, which have been evolved for marine service by the Rolls-Royce Company in collaboration with the British Power Boat Company, Ltd. Careful attention has been paid to the living accommodation and the ventilation, in order to make the boats suitable for operation under tropical conditions. The crew to be carried will in all probability consist of two officers and seven men. The boats, it is understood, will be designed for service in the North Sea and in the Dutch East Indies.

National Defence Precautions and Electricity Supply

IN a note issued by the Ministry of Transport on Tuesday, January 3rd, it is stated that, as already announced in Parliament, discussions have been taking place with representatives of public utility undertakings as to special measures to be taken by way of precaution in a national defence emergency. In the case of electricity undertakings the conclusion has been reached that, beyond the ordinary measures of air raid precautions which every good employer must be expected to take, the most practical measure will be the provision of a national reserve of switchgear, transformers, and incidental equipment, to be readily available for installation where required, to be held at suitable centres and to be under the administration of the Central Electricity Board. The cost of these measures, and certain other steps for the protection of plant outside the scope of ordinary "good employer" precautions, has been estimated at £3,000,000, and the Ministry of Transport, in consultation with the Lord Privy Seal, has authorised the Electricity Commissioners to inform the representatives of the industry that Parliament will be asked as soon as possible to undertake the liability for one-half of this total and to authorise the remaining half to be borrowed by the Central Electricity Board, interest, sinking fund, and other necessary charges being met by means of a levy upon authorised undertakers, on the lines of the levy which is already being made for standardisation of frequency.

A Dalmuir Arms Factory

ON Wednesday, January 4th, it was officially announced by the War Office that it has been decided to establish a Royal Ordnance Factory at Dalmuir, near Glasgow, and that arrangements have been made to take over an existing works which will be equipped for the manufacture of guns. The Lord Provost of Glasgow, Mr. P. J. Dollan, has since made a statement to the effect that the site referred to in the War Office announcement is that comprising the late yard and works of William Beardmore and Co., Ltd. The site has, we understand, been selected by the War Office on the grounds that besides being a well-developed site, it is one which will provide adequate transport facilities, not only by road and rail, but also by water. Although the new plant will not give employment comparable with that which was provided by the full operation of the Beardmore undertaking, it is estimated that about 2000 men will be engaged on work generally similar to that now carried on in the many establishments doing heavy engineering work in the district. It may be recalled that the Beardmore yard was acquired some time ago for dismantling by National Shipbuilders' Security, Ltd., as part of the programme for shipbuilding rationalisation. Since that time efforts have been made to interest industrial firms in the site, and at one time the making of a trading estate was considered. Although some small parts of the area have already been let to other firms, the main yard has remained practically derelict. It is, we understand, that portion of the works and yard which will now be taken over and developed as an arms factory by the War Office. On the other side of the Clyde a new projectile factory is approaching completion near Bishopton, while further developments include a new aircraft factory which will be built near the Abbotsinch aerodrome, and extensions to the Blackburn aircraft factory at Dumbarton. When all these works have been completed, it is expected that employment will be created in the district for approximately ten thousand workers coming within the category of the engineering trades.

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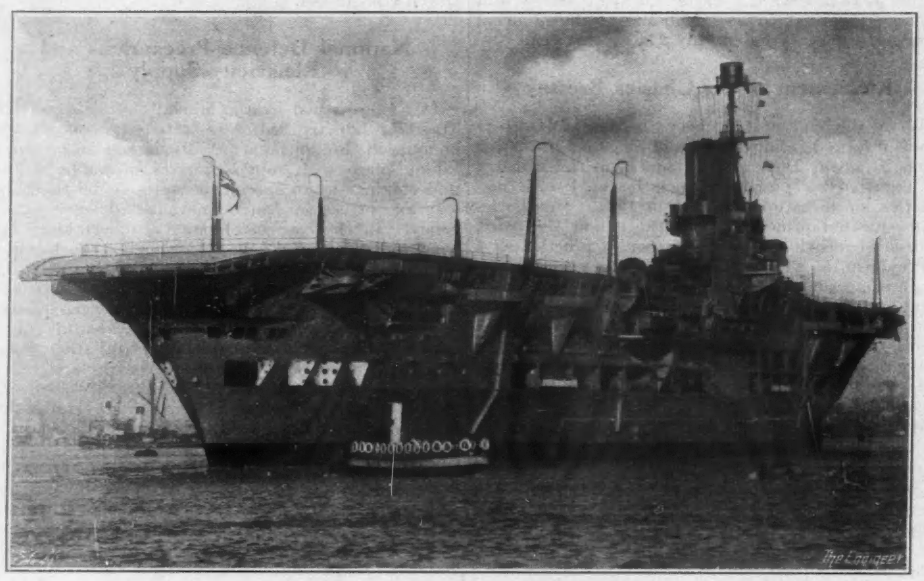
Naval Construction in 1938

By HECTOR C. BYWATER, A.I.N.A.

No. I

DURING the past year substantial additions to the shipbuilding programmes of the Naval Powers, both great and small, have raised the aggregate of current man-of-war construction in the world to a level never before attained in peace time. It may even be doubted whether in any year of the Great War the total naval tonnage under construction exceeded the present figure. The British Empire leads with over 600,000 tons, completing, on the stocks, or projected. Next comes the United States with approximately 400,000 tons. France and Italy have hitherto been running virtually neck and neck, but now the latter is drawing ahead. Germany, bent on reaching the full 35 per cent. ratio based on the British Empire's aggregate, as provided for by the agreement with this country, Germany, and Italy. Here only one vessel, and that a small minesweeper, has so far been built without rivets, though the structure of the large aircraft carrier "Ark Royal," is understood to be welded to the extent of 65 per cent. Naval construction has not escaped the upward trend of prices for materials, labour, &c., which has already produced a deadlock in British mercantile shipbuilding, and the warships now building and about to be laid down promise to be the most expensive, ton for ton, ever constructed for the Royal Navy.



H.M. AIRCRAFT CARRIER "ARK ROYAL"

British Empire

The battleship "King George V," laid down on January 1st, 1937, at the Walker-on-Tyne yard of Vickers-Armstrongs, Ltd., is to be launched on February 21st by H.M. the King. A sister ship, "Prince of Wales," also begun on January 1st, 1937, at the Cammell Laird yard, Birkenhead, should go afloat at an early date. Of the other three ships of this class, the "Duke of York" (ex "Anson") was started by John Brown and Co., Clydebank, in May, 1937; the "Jellicoe," by Swan, Hunter and Wigham Richardson, Wallsend, in July; and the "Beatty," by the Fairfield Company, Govan, in June of the same year. All these vessels should therefore be afloat before the end of 1939, and are due for completion in the financial year ending March 31st, 1941. Official details of the "King George V" class, other than the displacement, 35,000 tons, and the calibre of the main armament, 14in., are still withheld. This notwithstanding, information published in the Press enables a fairly accurate forecast of the type to be attempted. It differs radically from the "Nelson" class, which was designed seventeen years ago. As the "King George V" has an estimated standard displacement of 35,000 tons, her weight in seagoing condition cannot be less than 40,000 tons. The freeboard will be lower than that of the "Nelson," while the twin funnels and fore-and-aft disposition of the main gun positions will give the new vessel a "shipshape" appearance which her predecessor painfully lacks. The length is understood to be about 800ft., and the breadth is ample for the extraordinarily complete system of underwater protection which is known to be a feature of the design. Armour defence will no doubt be concentrated over vital parts, leaving the ends only lightly protected. Prolonged experiments were made before the lay-out of horizontal protection against plunging fire and aircraft bombs was settled. It may be said with confidence that the "King George V" and her consorts are as strongly defended as any of their foreign contemporaries, with the possible exception of the new American battleships. The maximum speed is reported as 30 knots, though the contract figure may be found to be rather lower than this. The main armament comprises ten 14in. guns of a new model. This is certainly a more powerful weapon in all respects than the pre-war 13·5in., which discharged a projectile of 1400 lb. The disposition of the main armament is understood to be as follows:—One quadruple turret on the forecastle, with a twin turret superposed in rear of it, and a quadruple turret on the quarterdeck. This arrangement gives a fire of six guns ahead and four astern. No details of the secondary or the high-angle armament can be added at present. Torpedo tubes have probably been omitted from the design. By the end of the current fiscal year a sum of £3,433,000 will have been spent on the "King George V" and a trifle less on the "Prince of Wales." This may prove to be less than 40 per cent. of the total cost.

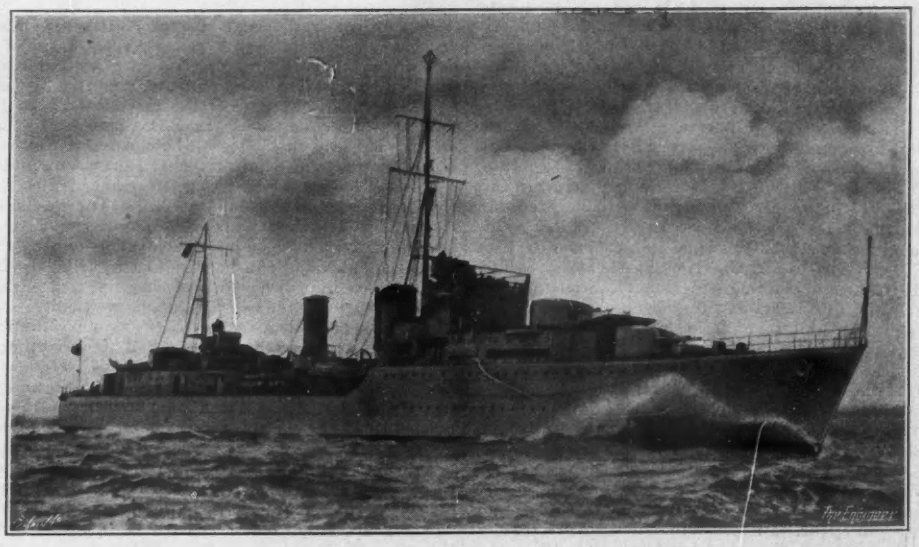
Two further battleships, to be named "Lion" and "Temeraire," are included in the 1938 programme, but neither has been contracted for at the time of writing. Designed under the escalator clause of the London Naval Treaty, 1936—which was invoked early last year because of Japan's refusal to disclose the size and armament of her new battleships—they will have a standard displacement of about 40,000 tons, and be armed with 16in. guns. This increase in size and gun calibre, though doubtless dictated by good reasons, does not command general approval in naval circles, where the former passion for "giantism" in ships and ordnance nowadays finds few adherents.

At the beginning of 1938 there were seventeen cruisers completing, building, or on order. Three of these—"Gloucester," "Liverpool" (see Supplement), and "Manchester"—have since been delivered. They are slightly enlarged editions of the "Southampton" class, displacing 9300 tons as against 9000, with a speed increased to 33 knots, but with the same main armament of twelve 6in. guns. The cost of these three ships has averaged £1,930,000. Two further cruisers—"Belfast" and "Edinburgh"—were launched during the year by Harland and Wolff, Belfast, and Swan Hunter,

is constantly adjusting her programme to conform to the progressive expansion of the British Navy, and hopes to reach the specified standard of relative strength by 1942 at latest. Japan, the "dark horse" in the naval race, still prefers to build in secrecy. The scope of her current programme is purely speculative, but it is a safe assumption that it has been drawn up with a view to maintaining the existing balance of power in the Pacific. Thanks to the Anglo-Russian bilateral treaty which provides, *inter alia*, for the exchange of information as to shipbuilding activities, the number and types of war vessels building in the U.S.S.R. must now be known in official circles here, though very little reliable information is available to the public.

Since the battleship is still the accepted master symbol of naval power, the number of these ships building at a given period provides a rough index to the extent of world rearmament at sea. During 1938 no less than thirty capital ships were building or projected in Europe, America, and Asia—this total excludes Russia altogether, but credits Japan with three units—and further ships are listed for commencement in 1939. This total is even more significant than it appears to be, for the proportion of battleships to cruisers and other light craft is much smaller to-day than it was in pre-war years, owing chiefly to the enormous cost of the modern capital ship. The very substantial cruiser, destroyer, and submarine programmes now in process of execution in many countries swell the world aggregate of fighting tonnage to dimensions never previously attained, even in wartime. It remains a complete mystery how such States as Germany, Italy, and Japan are sustaining the burden imposed by their colossal armament budgets, of which naval construction is but one item. The most eminent economists confess themselves baffled by this problem.

On the technical side no outstanding developments are to be recorded. The use of electrical welding is making steady headway, though more slowly in Great Britain than in the United States,



H.M. TRIBAL CLASS DESTROYER "AFRIDI"

Wallsend, respectively, and are now approaching completion. With a length of 579ft. between perpendiculars, a beam of 63ft. 4in., and a displacement of 10,000 tons, they are appreciably larger than the "Gloucester." The speed is 32½ knots. While the main armament of twelve 6in. guns remains unaltered, the high-angle battery has been increased from eight to twelve 4in. guns, and there is some improvement in protection. Broadly speaking, however, these ships belong to the "Southampton" group, which thus numbers ten units. Although inferior, on paper, to the United States and Japanese cruisers of cœval design, the "Southamptons" are most successful ships in all aspects, and those in service have given complete satisfaction. The following cruisers are still under construction or consideration:—

"Fiji" Class

"Fiji"	John Brown and Co., Clydebank
"Kenya" ...	A. Stephen and Sons, Govan
"Mauritius" ...	Swan, Hunter, Wallsend
"Nigeria" ...	Vickers-Armstrongs, Walker-on-Tyne
"Trinidad" ...	H.M. Dockyard, Devonport
"Ceylon" ...	Contract not yet placed
"Jamaica" ...	Ditto
"Gambia" ...	Ditto
"Uganda" ...	Ditto

Displacement, 8000 tons; main armament reported to be twelve 6in. guns.

"Dido" Class

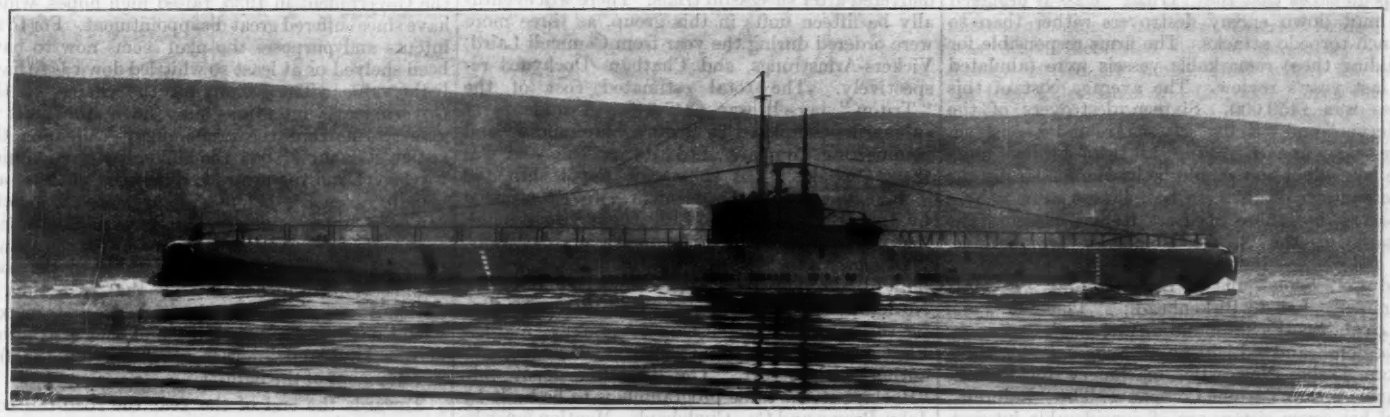
"Dido"	Cammell Laird, Birkenhead
"Euryalus" ...	H.M. Dockyard, Chatham
"Naiad" ...	Hawthorn, Leslie, Newcastle
"Phœbe" ...	Fairfield Company, Govan
"Sirius"	H.M. Dockyard, Portsmouth
"Bonaventure"	Scotts' Shipbuilding Company, Greenock
"Hermione" ...	Stephen and Sons, Govan
"Charybdis ...	Cammell Laird, Birkenhead
"Cleopatra ...	Hawthorn Leslie, Hebburn
"Scylla" ...	Scotts' Shipbuilding Company, Greenock

Displacement, 5450 tons; armament reported to consist of ten 5·2in. guns.

It will be noticed that the "Fiji" class conforms to the limit of 8000 tons imposed on cruising ships by the London Treaty of 1936. This maximum must not be exceeded before the year 1942. It is satisfactory to find that despite the reduction in size these ships retain the same main armament as the larger "Southampton" class. As regards the "Dido" class, they represent an improvement on the "Arethusa" type, 5220 tons, 32¼ knots, which suffer from the weakness of their armament of six 6in. guns as compared with that of foreign cruisers of equal or less tonnage. A larger number of 5·2in. guns will enable the "Dido" type to deliver a superior volume of fire, a factor of greater importance than weight of projectile in the duties likely to fall to small Fleet cruisers. The completion of the nineteen vessels listed above will raise to fifty-four the total of the Empire's post-war cruising ships, leaving a deficit of six in the minimum establishment of under-age cruisers prescribed by the Government's naval policy.

As far as can be gleaned from the meagre details at present available, the current cruiser programme is a well-balanced one, and the design of individual groups leaves little to be desired. The building of large blocks of ships of uniform type should simplify the problems of maintenance, replenishment, and repair, and therefore conduce to economy. It is, however, a policy which can be pursued only when, as at present, ample funds are diverted to naval construction.

The aircraft carrier "Ark Royal"—see also Supplement—was commissioned on November 22nd as flagship of the rear-admiral commanding aircraft carriers. The original date of completion was mid-September, but owing to the entirely novel design of the ship and her equipment the trials were unexpectedly prolonged. Authorised under the 1934 Estimates, the "Ark Royal" was not begun until September, 1935, when the keel was laid at the Cammell Laird yard, Birkenhead. The launch took place on April 13th, 1937. The ship has a standard displacement of 22,000 tons and is 685ft. long b.p., her breadth being 94ft. She is propelled by geared turbines taking steam from water-tube boilers of the three-drum type and developing 102,000 S.H.P. for a speed of 30¾ knots. This figure was comfortably exceeded on trials. Details of armour and other protection are withheld, but there appears to be a partial belt on the water line. For a vessel of this class the armament is fairly powerful. It consists of sixteen 4·5in. guns on special mountings which permit both of high and low-angle fire. The first guns of this calibre to appear in the Navy were mounted in the submarine depôt ship "Maidstone," completed last May. In the "Ark Royal," being twin-mounted on sponsons carried well out from the sides of the ship, they have a field of fire much superior to that of the armament of earlier carriers. They are supplemented by six multiple pompoms and eight multiple machine guns. The two-storied hangars can accommodate about sixty aircraft, the total capacity depending on the types of aeroplanes on board. Machines are taken to and from the flight deck by three hydraulic lifts. This deck, which runs without a break the full length of the ship, measures 800ft. by 90ft., is fitted with arrester wires for checking the way on "landing" aircraft, and is unobstructed save for the "island" on the extreme starboard side, which houses the bridge unit, funnel, and mast. Aircraft on deck are fuelled by pipes leading from the petrol tanks far below. Precautions against fire are most elaborate and are claimed to be foolproof. The "Ark Royal's" full complement is 1600 officers and men, including 140 officers borne for flying duties. The quarters both for ranks and ratings are unusually spacious and comfortable and possess amenities found in no other warship afloat. The total cost of the "Ark Royal" was £3,215,639.

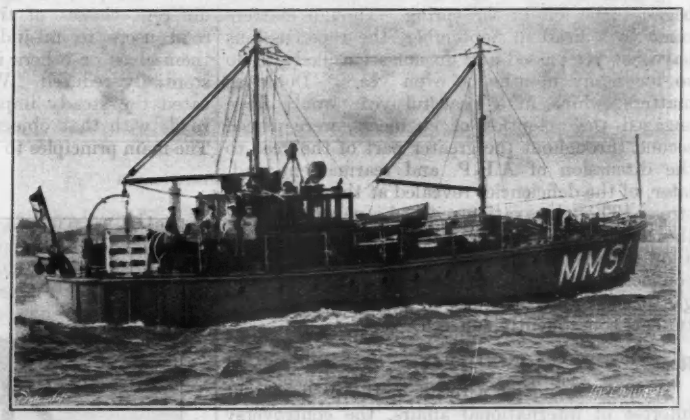


H.M. MINELAYER SUBMARINE "CACHALOT"

Four further aircraft carriers of the same general type, but of 23,000 tons, are under construction: "Formidable," by Harland and Wolff, Belfast; "Illustrious" and "Indomitable," by Vickers-Armstrongs, Barrow-in-Furness; and "Victorious," by Vickers-Armstrongs, Walker-on-Tyne. These ships were voted in 1936 and 1937. Yet another carrier, "Implacable," was authorised in 1938, the contract for this ship being awarded to the Fairfield Company, Govan, in October. Assuming her to be a sister ship to the others, we shall possess by 1940–41 six large modern carriers, costing, at a very conservative estimate, £21,000,000. They will take to sea a total of about 360 aircraft, not all of which may be available for simultaneous service, and will absorb nearly 10,000 officers and men. When to these figures is added the fact that the large aircraft carrier is, of all naval vessels, the most vulnerable to every form of attack, a doubt will arise in many minds as to the wisdom of building these great ships.

The sixteen "Tribal" class destroyers ordered in 1936 should all be in service before March 31st, 1939. In most cases the building period has averaged rather less than two years, which is creditable enough considering the novelty of the design and the shortage of materials and labour induced by the rearmament programme. As the largest and most heavily armed torpedo craft yet built for the British Navy, they have attracted much attention at home and abroad. Displacement, 1870 tons; length b.p., 355ft. 6in.; breadth, 36ft. 6in.; draught, 9ft.; Parsons geared turbines; three Admiralty three-drum boilers; estimated H.P., 44,000=36½ knots. The armament comprises eight 4·7in. guns, paired in gun-houses open at the rear; eight smaller pieces and four 21in.

H.M. MOTOR TORPEDO BOAT NO. 102



H.M. MOTOR MINE SWEEPER "MMS1"

torpedo tubes. Although the 4·7in. guns are not on A.A. mountings, they have a high angle of elevation. In these ships a new form of hull has been adopted with remarkable success as regards speed, stability, and behaviour under helm. Commanding officers of the "Tribals" speak with enthusiasm of their performance under all conditions of weather. The sharply raked stem, high forecastle, unequal funnels, and tripod masts lend them a characteristic appearance more suggestive of Continental than British practice. The type is unquestionably a pronounced success, and the completion of its sixteen units provides a much-needed counterpoise to the heavy destroyers of certain other navies. It is clear from the formidable gun armament and the limited number of torpedo tubes that the "Tribal" class is designed to hunt down enemy destroyers rather than to launch torpedo attacks. The firms responsible for building these remarkable vessels were tabulated in last year's review. The average cost of this class was £450,000. Sixteen destroyers of the "Jervis" and "Kelly" classes are under construction, eight in each group. All the "Jervis" units are now afloat and should be in commission by the late summer of 1939, to be followed after a brief interval by those of the "Kelly" class. The vessels of the "Laforey" class are building as follows:—"Laforey" and "Lance," Yarrow and Co., Scotstoun; "Larne" and "Lively," Cammell, Laird, Birkenhead; "Lookout" and "Loyal," Scott's Shipbuilding Company, Greenock; "Legion" and "Lightning," hulls only by Hawthorn Leslie, Newcastle, machinery by Parsons Marine Steam Turbine Company. The "Laforey" and her seven sisters are of considerable interest, for they exceed in size even the "Tribals" and will thus be the heaviest torpedo vessels ever built for the British Navy. As compared with the 1870 tons of the "Tribals," the "Laforey" and her sisters will displace 1935 tons, the speed being 36½ knots. The reported armament of six 4·7in. guns seems rather light, and may turn out to be heavier. The "J" and "K" destroyers represent an intermediate type as compared with the 1870-ton "Tribals" and the 1370-ton ships of the preceding class, their displacement being 1690 tons; length, 348ft.; breadth, 35ft.; 40,000 S.H.P. for 36 knots; six 4·7in. guns; ten torpedo tubes. Together with the "Tribals" and the still larger vessels of the "Laforey" class, they will constitute a force of forty heavy destroyers, of which the Navy stood in urgent need. No destroyers were included in the 1938 programme, but one or two flotillas are likely to be provided this year. It is suggested by many naval officers that, side by side with the heavier classes, the Admiralty might profitably develop a smaller type of destroyer, say, of 850 to 1000 tons, which could be built comparatively cheaply and quickly. A great number of small destroyers or torpedo boats are being built for the French, Italian, Japanese, and German navies, and there is good reason for supposing that they would be of equal value to this country. There will never be enough destroyers in an emergency, and if we continue to build only large and expensive types, the shortage is bound to become acute.

Turning to submarines, several boats of the "Triton" ocean-going class, 1095 tons, have been delivered after successful trials. There will eventually be fifteen units in this group, as three more were ordered during the year from Cammell Laird, Vickers-Armstrongs, and Chatham Dockyard respectively. The total estimated cost of the "Triton" herself was £347,649. A mine layer submarine completed by Scott's Shipbuilding and Engineering Company, Ltd., during the year was the "Cachalot." A submarine depôt ship, the "Maidstone"—see Supplement—was completed by John Brown and Co., Ltd. Last year's building programme included the minelayers "Abdiel," "Latona," and "Manxman." One each will be built by Alex. Stephen, Thornycroft, and J. S. White. No details are known. Contracts are still outstanding for the submarine depôt ship "Adamant" and the Fleet Air Arm supply and repair vessel "Unicorn" authorised last year. The destroyer depôt ship "Hecla," of the same programme is to be built by John Brown and Co., Clydebank. Mention must be made also of the river gunboats, "Locust" and "Mosquito," building by Yarrow, and of the five boom defence vessels ordered from the Blyth Dry Docks Company. Including these five, there are now twenty-two boom defence vessels in hand.

Two other interesting naval vessels were the Vosper-built motor torpedo boat "102," and the Thornycroft motor mine sweeper "MMSI."

In September the cruiser "Apollo" was transferred to the Australian Navy and renamed "Perth." Her sister ship "Amphion" will be similarly transferred next July and receive the name "Hobart." Two escort vessels "Warrego" and "Parramatta" are building at Sydney, where two "Tribal" destroyers are shortly to be laid down.

(To be continued.)

Roads, Bridges and Tunnels in 1938

THE year 1938 was overshadowed by the growing international crisis, the effects of which began to be felt in the spring. Though matters came to a head in September, the repercussions have not yet passed and do not seem likely to do so for many months or even years. Domestic matters, which in a peaceful year would have engaged the attention of engineers, were placed second throughout the greater part of the year to the discussion of A.R.P. and rearmament and, later, of the deficiencies revealed at the moment of stress. Though taxation reached a new high level, the national revenue was deemed insufficient to allow for any increases towards things less directly connected with defence than guns, aircraft, and gas masks. Expenditure on roads, bridges, and tunnels consequently suffered.

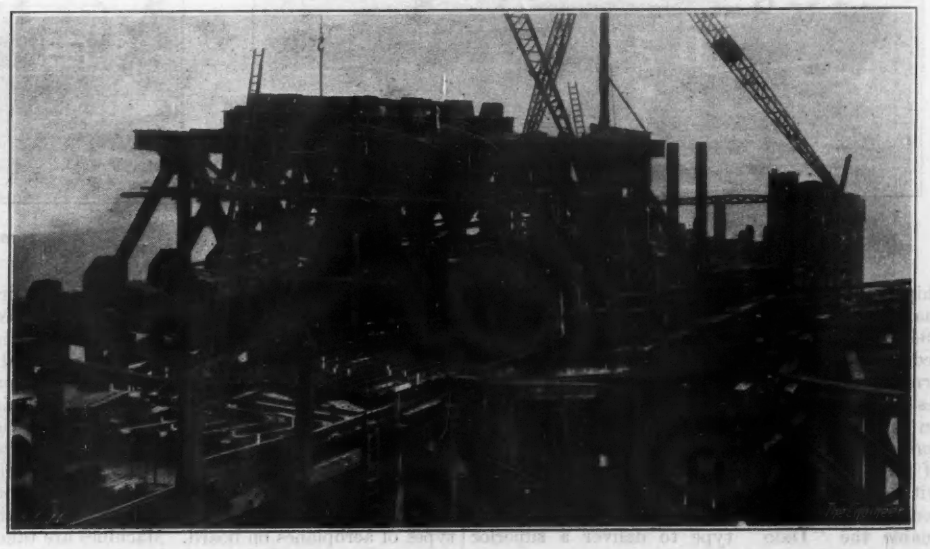
Roads

Whether or not as a result of the predominant interest of international affairs, the controversy that raged so fiercely a year or two ago over the causation of road accidents died down. The more likely reason for the lack of interest shown by the public, if not by engineers and others more directly concerned, seems to us to have been the more or less unanimous acceptance by the contending parties of each other's point of view. It is quite clearly obvious that were everybody, all the time, careful and considerate in using the roads accidents would be far less frequent even on the less well-designed highways. Consequently propaganda and education intended to impress on each road user, whether pedestrian, cyclist, or driver, that he has responsibilities towards others cannot but do good. But it is equally obvious and of more active interest to engineers that by the improvement in the lay-out and construction of roads and particularly by the segregation of the different classes of traffic the opportunities for road users to misjudge events and thus bring themselves or others into peril can be very substantially reduced. We have consistently advocated the steady improvement of this country's roads with that object in view for several years. The main principles to be followed in designing and laying out highways have now been more or less agreed upon, and as long ago as 1937 the Ministry of Transport laid down certain standards. Research in 1938 was thus directed more particularly to the improvement of the technique of road making and dealt with earthworks, drainage, the characteristics of concrete, tar, bitumen, &c., and the production of skid-proof surfaces.

But though interest in the means to be adopted to bring about a reduction of accidents died down as agreement became more unanimous, there still remain subjects for controversy and complaint. Road users and particularly the road transport industry are far from satisfied by the rate at which road improvement is proceeding. The £100 million five-year road plan, announced by the Government in 1935, raised high hopes, which have since suffered great disappointment. For to all intents and purposes the plan seems now to have been shelved or at least so whittled down as to have little value. The reason for the change of the Government's intentions may lie in the need to give rearmament the predominant call upon the nation's finances, but the difficulty of obtaining wayleaves and the protracted negotiations that are usually necessary before two or more authorities can agree upon a common plan have no doubt been another factor. Whatever the reason for the change of heart, the position is unpalatable to the road organisations, which point out that in a time of national emergency roads and road transport would be of great importance and that restrictions of one kind and another are hindering the free development of the industry.

Towards the end of the year the road-rail controversy threatened to break out again when a deputation from the railways waited upon the Minister of Transport. The railways found during the year that they were suffering a reduction of receipts. In December they began a publicity campaign to bring their grievances before the notice of the public. As, however, the demands made were no longer for increased restriction upon road transport, but for de-restriction of the railways themselves, the sympathy rather than the hostility of the road organisations seems to have been aroused. In this more happy condition of affairs the condition seemed ripe for the Government to review the whole field of transport, including that by rail, road, canal, and sea, with the object of putting matters on a basis which would be agreed to as fair by all. In mid-December the Minister, after a further conference with the railway representatives, put the matter into the hands of the Traffic Advisory Committee for further examination.

Undoubtedly the event of greatest interest during the year was the publication of the Highway Development Survey (Greater London) by Sir Charles Bressey and Sir Edwin Lutyens, better known as the Bressey Report. The alteration of cities to suit the needs of modern traffic has set engineers a problem which will tax their powers to solve in an economic manner. Land values in certain parts have reached such enormous values that the cost of major alterations has become prohibitive. In London, during the last few years, little real attempt has been made to solve the problem and the increased flow of traffic has been accommodated and kept reasonably free by the application of such palliatives as traffic lights and



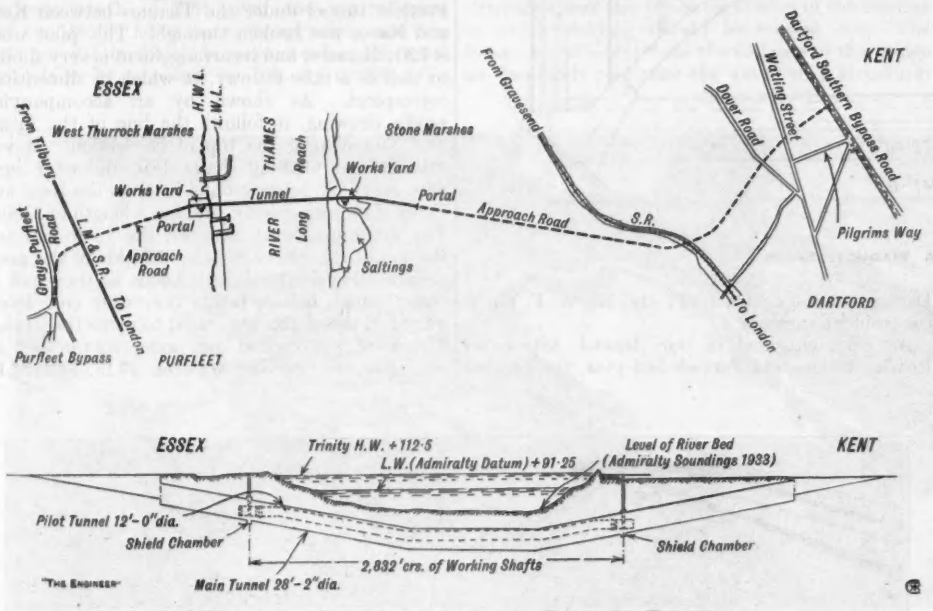
WANDSWORTH BRIDGE UNDER CONSTRUCTION

"roundabouts." But with the increase of traffic showing no signs of abatement the day when more radical improvements will be necessary cannot be much longer postponed. The Bressey Report, without laying down in detail how certain streets and roads should be widened or made anew, plans the development of new routes all over Greater London, describing the purpose and intention of each improvement. The detailed siting of the routes is left to the agreement of the local authorities, who will be responsible for carrying out the works envisaged during the next thirty years. It is a severely practical document and contains no revolutionary proposals, although those for a tunnel under the Park and for viaducts in South London may have proved disturbing to the more conservatively minded. On its issue it received general commendation, was accepted by the Government, which has taken the appropriate steps to give effect to its more urgent recommendations so far as they effect trunk roads and was delivered to the local authorities, with which the initiative for further action will rest. It is the hope of all those with the interests of London at heart that its provisions will not in course of time be whittled down by conservatism, prejudice, and an unwarranted respect for property and vested interest.

Despite the shelving of the Five-Year Plan and the retarding effect of the cost of rearmament, a considerable amount of road work was carried out during the year. Details cannot be entered upon here, but reference may be made to the scheme of the London County Council for the improvement of the south bank of the Thames between Westminster and a point downstream of Waterloo Bridge. Powers are to be sought from Parliament for the compulsory acquisition of property in connection with the construction of an embankment on the south side providing an open space 100ft. wide beside the river and a riverside promenade, together with the realignment of the approach to Waterloo Bridge and the widening and reconstruction of several streets. The total cost is estimated to reach more than £1,600,000.

Bridges and Tunnels

Work upon bridges and tunnels in this country was deeply affected by the predominant financial needs of the defence services. Further progress for instance, with the schemes for road bridges over the Severn, the Forth, the Humber, and the Tay, and other structures, is held up by the refusal of the Government to offer any grant towards their construction. But in July Dr. Burgin, after pointing out that none of them were agreed schemes, stated with regard to the Severn project that if the parties concerned could reach agreement as to the type of bridge, its site, and the advantage to the counties on each side of the estuary, the Government would be prepared to re-examine the proposals. In the North a new proposal originated during the year at a conference of authorities interested in Tyneside cross-river traffic for a tunnel between Jarrow and Howden. Such a work, it was estimated, would cost about £5,000,000. A technical and financial investigation of the prospects of such a tunnel is to be made. Like the projects for bridges just mentioned, this scheme, too, seems likely to meet with the same fate.



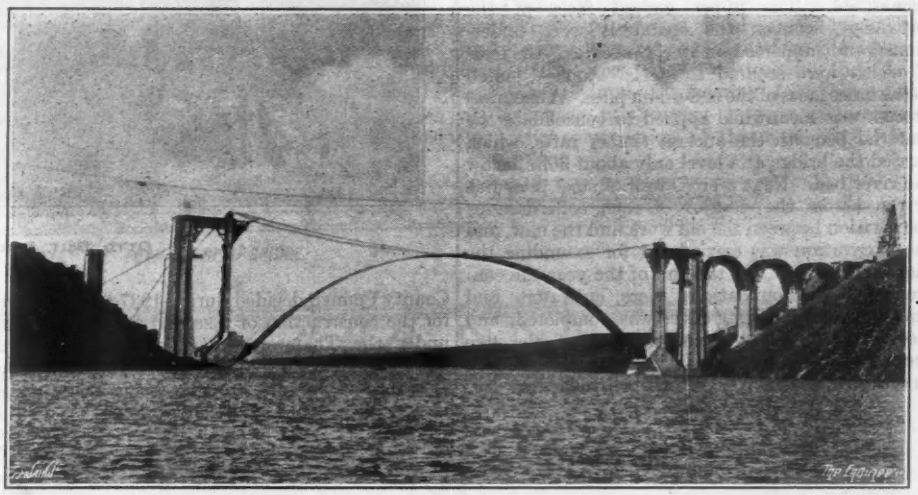
[PLAN AND PROFILE OF DARTFORD-PURFLEET TUNNEL

The work upon bridges and tunnels is in progress is mainly concentrated about the London area, where two Thames bridges and one under-Thames tunnel are under construction, and one bridge is being widened and another tunnel about to be started. Elsewhere the only work of major interest appears to be that of reconstructing the Menai Bridge in Wales. A bridge on the Selby by-pass in Yorkshire is, however, worthy of passing notice. Work upon it will be begun early this year, and it will cross the river Ouse. The bridge is to have a width of 84ft. and to be of the double bascule Scherzer rolling lift type with leaves each 60ft. long. Sir Alexander Gibb and Partners, of Westminster, are the engineers.

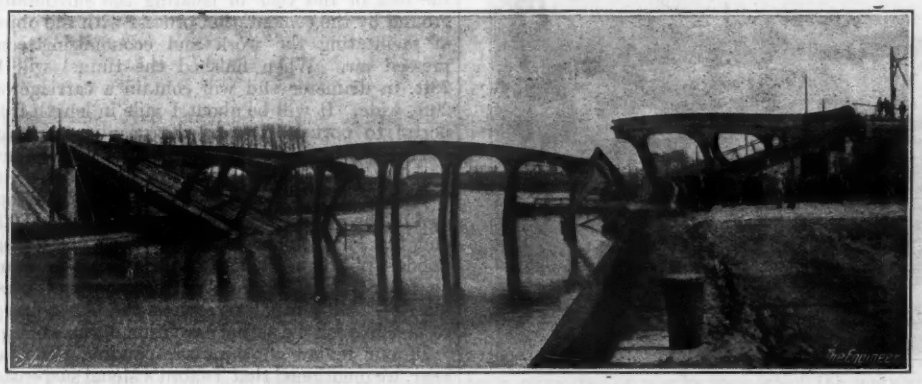
London

Rapid progress was made during the year with the construction of the new Waterloo Bridge. It was much facilitated by the temporary crane gantry carried by timber piles which the contractors, Peter Lind and Co., Ltd., have thrown across the river. This structure together with the temporary bridge erected by Sir William Arrol and Co., Ltd., at the time when the old bridge first failed some years ago, are prominent in the photograph reproduced in one of the pages of our Supplement. The work having been mainly concerned with the finding of foundations and the building up of the piers, there is at present, however, little for the ordinary onlooker to see, except the gantry. The latter was described in our issue of August 26th. There are several matters of considerable interest in connection with the design of the bridge, but as they were all mentioned in an article in our issue of December 16th (only three weeks ago), there is no need to repeat our description in detail. The new bridge, which will carry a roadway, 60ft. wide, and two pathways, to make a total width of 80ft., will be carried on five spans, the three central ones 252·7ft. and the shorewards spans 242·7ft. long. It is being constructed for the London County Council under the direction of Messrs. Rendel, Palmer and Tritton, of Westminster, in association with Mr. T. Peirson Frank, chief engineer to the Council. It will be a reinforced concrete structure, faced, as to the superstructure, with Portland stone and, as to the piers, with granite from the old bridge. The construction gantry was pushed out during the year from the southern shore, and work was begun on the four river piers in succession as it reached them. Thus whereas piers Nos. 3 and 4, closest to the southern bank, were nearly completed, work was less advanced within the cofferdam for pier No. 1. Sir Giles Gilbert Scott is the architect.

Old Wandsworth Bridge, which was subject to a weight limitation, was demolished in 1937. During 1938 work was proceeding on the erection of the new cantilever structure, with a central span of 283ft., which replaces it. This bridge was designed by Mr. T. Peirson Frank, in collaboration with Mr. E. P. Wheeler, chief engineer and architect respectively to the London County Council. The contractors are Holloway Brothers (London), Ltd., and the cost is expected to reach £400,000. During the year the two river piers and the abutments were completed, and the cofferdams within which work had proceeded were removed. The bearings were fixed to the top of the main piers, and staging for the erection of the anchor arm steelwork was built. In November the first consignment of steel for the superstructure arrived, and by the end of the year more than 500 tons had

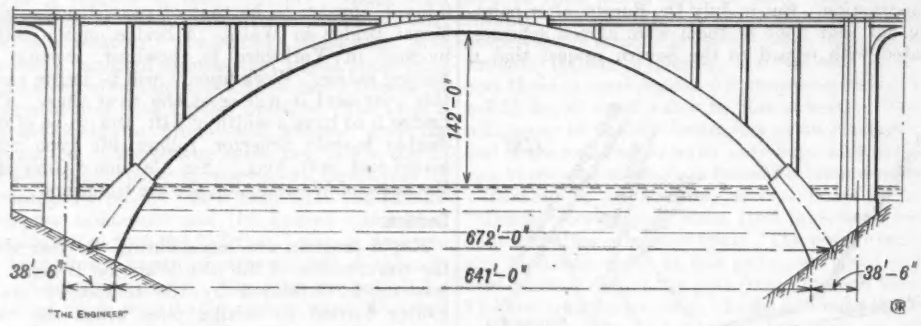


ESLA VIADUCT, SPAIN



HASSELT WELDED BRIDGE AFTER COLLAPSE

been built into the bridge. No staging will be used for the construction of the cantilever arms, which are to be cantilevered out across the river. In connection with the reconstruction of the approaches, steel girders, so as to impose as little restriction on river traffic as possible. Sir Harley Dalrymple Hay is the consulting engineer for the work; the Cleveland Bridge and Engineering Company, Ltd., of Darlington, the contractors; and Mr. W. F. Ware, the resident engineer.



ELEVATION OF ESLA VIADUCT, SPAIN

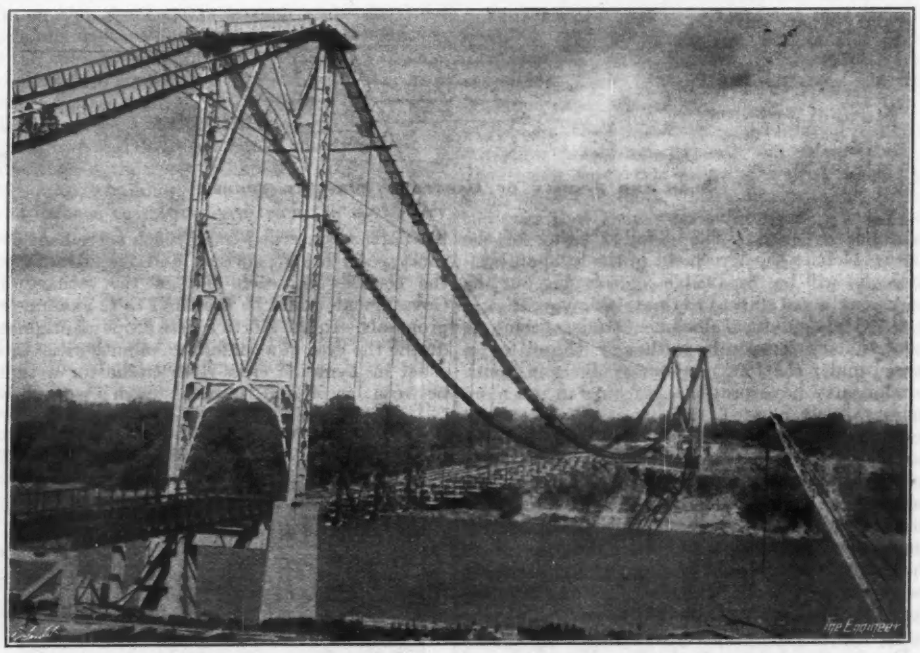
As we mentioned in our Annual Article on Roads, Bridges and Tunnels last year, the London County Council decided during 1937 to seek powers for the construction of a second Blackwall Tunnel under the Thames. In July of last year the Bill resulting from that decision received the Royal Assent, and surveys are now being made on the proposed line of the new tunnel and further trial borings will shortly be sunk. The new tunnel will probably be driven some 800ft. downstream from the old one, and will have a carriageway 20ft. wide. When it is completed one-way traffic working will be instituted in the two parallel tunnels. The cost is estimated to exceed £3,000,000.

In October the pilot tunnel for the Dartford–Purfleet tunnel under the Thames between Kent and Essex was broken through. This pilot work is 12ft. diameter and its arrangement is very similar to that of a tube railway, to which its dimensions correspond. As shown by an accompanying profile drawing, it follows the line of the future 28ft. tunnel near the top of its section. It was driven from working shafts 18ft. diameter sunk 82ft. and 71ft. below ground level on the Kent and Essex sides respectively, and has a length of 3300ft. The minimum cover between the river bed and the top of the tunnel is 25ft. Shields of the usual Greathead type, fitted with hoods as they had to pass through ballast before they were completely buried in the chalk, were used to drive the tunnel. The work was carried out under compressed air at a pressure varying between 27 lb. and 35 lb. per square inch, well below the theoretical pressure due to head of water in the ground. Besides the pilot tunnel the contract awarded to Charles Brand and Son, Ltd., included the construction of shield chambers at the bottom of each shaft for the driving of the main tunnel. Each of these chambers is 35ft. diameter and 28ft. 6in. long, and they were constructed by the enlargement of the 12ft. tunnel first to 23ft. 2½in.—a standard size for tube station tunnels—and then to the full dimension. By adopting this practice as little ground as possible was exposed at any one time, thus reducing the danger of a "run-in." The Essex chamber was completed in September; but owing to the more difficult nature of the strata on the Kent side that chamber was only finished recently. The pilot tunnel has revealed the nature of the work to be done in enlarging the tunnel, and experiments were being carried out towards the end of the year in treating the surrounding ground by the cementation process with the object of facilitating the work and economising compressed air. When finished the tunnel will be 28ft. in diameter and will contain a carriageway 20ft. wide. It will be about 1 mile in length from portal to portal. During the year preparations were begun for the construction of the viaducts on which the Essex approach road will be carried over the L.M.S. Railway to Tilbury. The total cost of the project is expected to reach £3,500,000, and the joint engineers to the work are Messrs. Coode; Wilson, Mitchell and Vaughan-Lee, and Messrs. Mott, Hay and Anderson, both of Westminster. By mutual agreement the latter firm is responsible for the actual execution of the works.

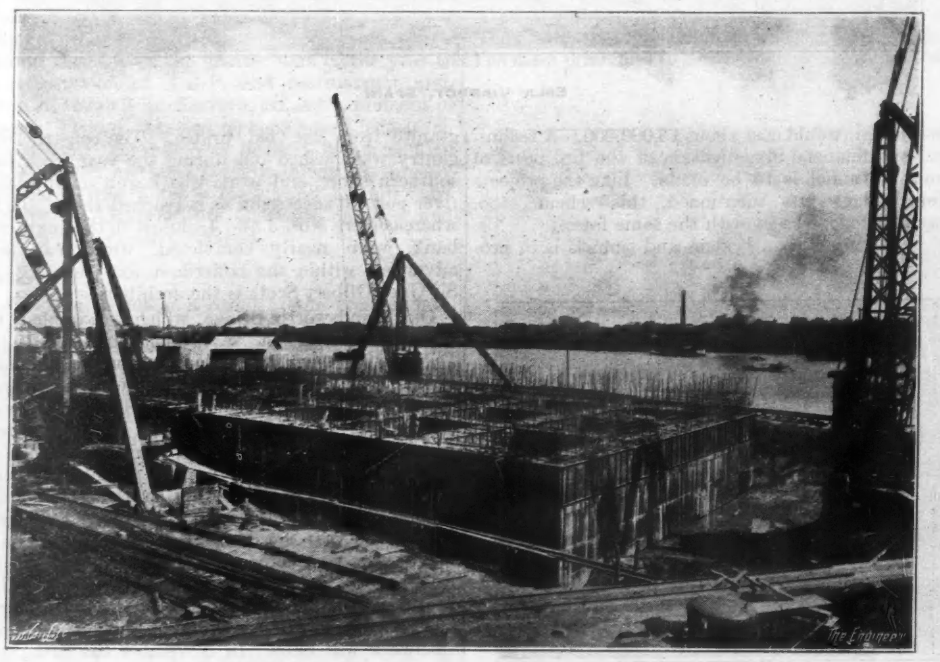
In our review in the corresponding issue last year, we mentioned that Telford's Menai suspension bridge was to be reconstructed under the super-

piled retaining walls were completed on the northern side and the filling for raising the road level placed, whilst at the other side the building of a reinforced concrete approach viaduct was almost completed.

In the spring of 1937 we published an illustrated account descriptive of the methods to be adopted in widening the ancient five-arch bridge across the Thames at Richmond. It will be recalled that the roadway width is to be increased to 21ft. from 16ft. 10in., and that there are to be two 7ft. 6in. pavements instead of a narrow strip on each side. The bridge is being widened on the upstream side, and the stones removed from the old bridge are to be replaced as a facing for the new concrete work. During 1938 the Twickenham and Richmond abutments, together with the arched approaches, were completed up to the underside of road level. A "lead-in" of timber pile dolphins, extending 175ft. upstream and 75ft. downstream, 45ft. wide under the bridge, was constructed to facilitate the passing of river craft through the central arch whilst work is in progress. Steel sheet piles were driven completely round each pier exactly in accordance with plans, and the old upstream cutwaters and buttresses below springing level were dismantled. The upper curved faces of the buttresses between the spandrels were underpinned and supported on steel "needles," the ends of which were secured to steel "stools" bolted to the inner faces of the cofferdam piles. A chemical process was meanwhile applied to consolidate the material beneath the ancient timber rafts, which carried the bridge at a level only about 30in. below the river bed. Next a cross wall of steel piles was driven across the interior of each cofferdam at the division between the old work and the new, and the excavation was carried out for extending the pier foundations. By the end of the year the concreting of the foundations, piers, cutwaters, and buttresses to springing level was completed, and steel centring for the construction of the five arches had been erected. Over the central span this centring is suspended on steel rods from two

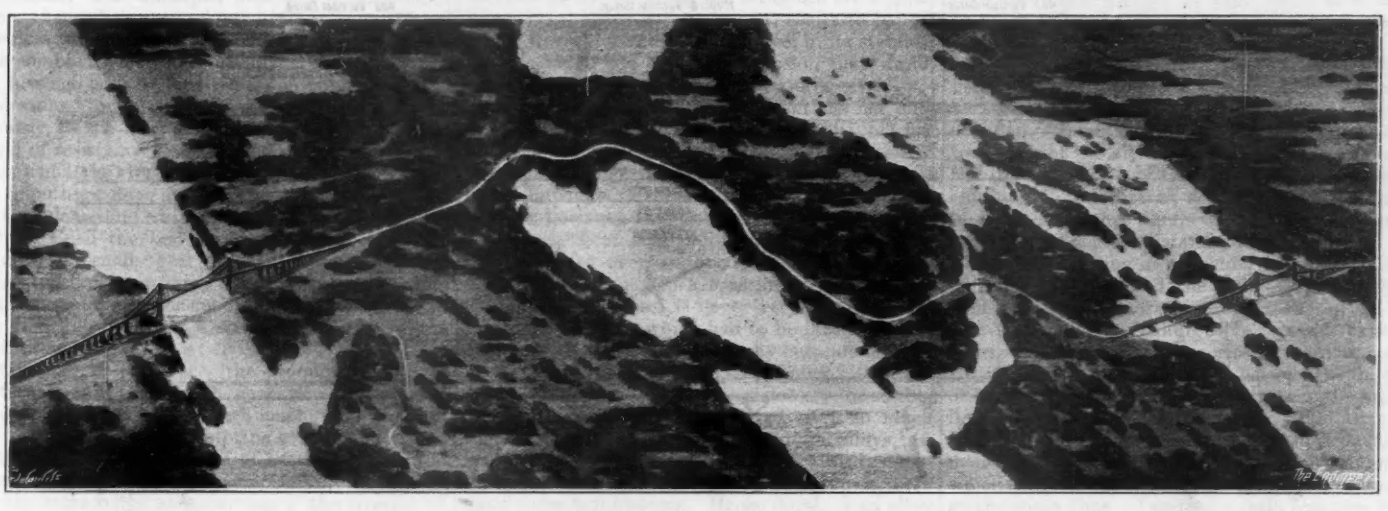


OTTO BEIT BRIDGE UNDER ERECTION



SINKING FOUNDATION MONOLITH FOR HOWRAH BRIDGE

vision of Sir Alexander Gibb and Partners, of Westminster. The bridge was erected more than 100 years ago, and being designed to suit horse traffic was found unsuitable for the heavier and more numerous loads it is now called upon to bear. It had two narrow lanes for traffic, and the arrangement of footpaths was unsatisfactory. When reconstructed the bridge, though very little altered in appearance, will have a clear roadway width of 23ft. over the central span and two traffic lanes on each approach, and the footways will be 5ft. wide on each side. The total width is to be increased by 10ft. up to 39ft. To carry the consequent increased loads the steelwork of the bridge requires to be at least twice as strong as that of the old structure, but by the use of modern steels the change is being effected with little alteration to the appearance of the bridge. The masonry work, however, was so carefully designed and constructed by Telford that it has been found capable of carrying the increased loads without any significant alteration. The twin archways, one over each traffic lane, are to be retained.



THOUSAND ISLANDS BRIDGES OVER ST. LAWRENCE RIVER

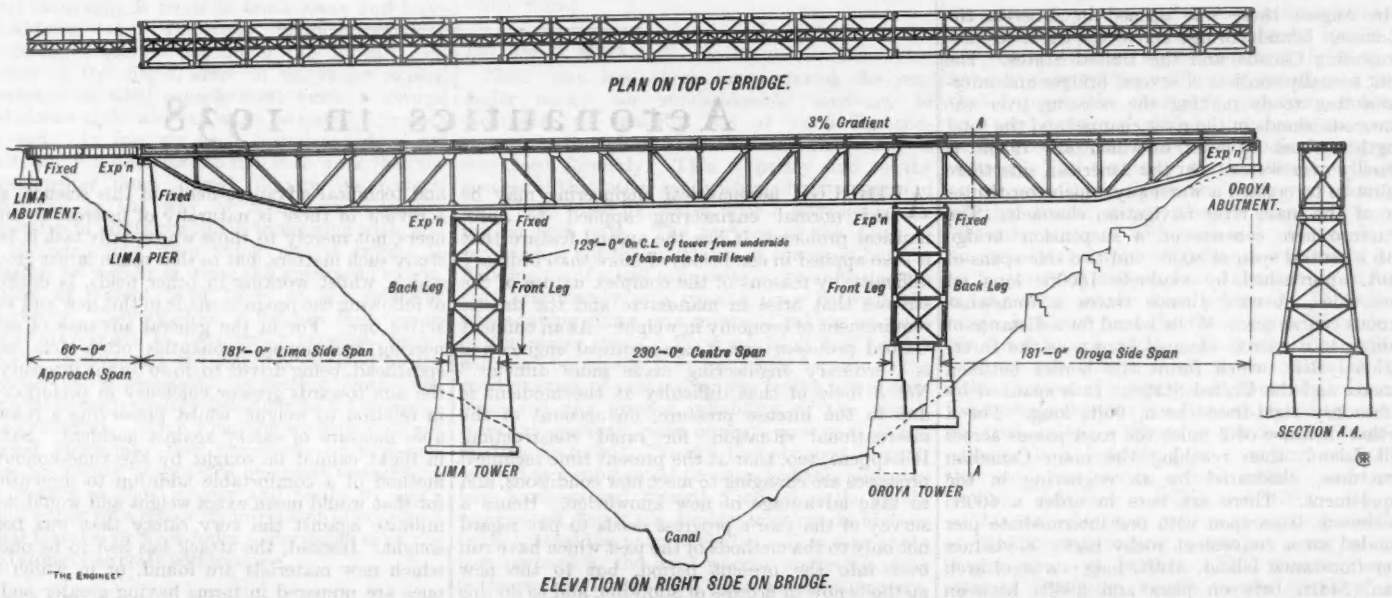
Europe

In March there occurred in Belgium the sudden and apparently inexplicable failure of a Vierendeel welded bridge over the Albert Canal at Hasselt. The bridge had a span of 74 m. 52, and a weight of 646 metric tons. Happily no personal injury was caused by the collapse as no one was on the bridge at the time. Two tramcars were about to pass over it. The first fracture occurred in the lower member of one of the main Vierendeel girders, and during a subsequent period of about six minutes other members overstrained by that failure themselves broke, and the bridge finally collapsed in three pieces as shown by an accompanying engraving. The bridge had been in service a year and a half, and had been subjected in January, 1937, to the regulation test loads of the national administration with complete success. The cross sections where the fractures occurred were rough and showed no trace of being torn apart or signs of elongation or contraction of area. There seems to have been an absence of ductility in the metal mass. Various explanations were put forward to account for the failure, and it has directed attention to the particular care necessary not merely in designing such structures, but also in the regulation of the manner in which welding should be carried out. The lessons to be learnt from the collapse of the bridge are less likely to hinder the use of such structures than to benefit the progress of the technique of welding.

In Spain, despite the civil war, work still seems to have been proceeded with, although at a slow pace, on an interesting reinforced concrete arched railway bridge on the line between Zamorra and Corunna, over the River Esla. This structure is designed to carry a double track of Spanish gauge with a loading of 25 tons per foot run on each rail. The design of the bridge is shown in an accompanying drawing. The central arch has a span of 672ft., but owing to the fact that the central line of the abutments is a continuation of the line of the arch, the span upon which calculations have been based is of 562ft. only. The arch is to be formed in a three-cell box section and will have a width of 29ft. 8in. at the springing and 26ft. at the crown, the corresponding thicknesses being 18ft. and 14ft. 10in. Timber centring to carry the concrete for the arch was in place early in the year, but information is lacking as to what further progress was made. This centring is carried by the suspension bridge seen in the half-tone engraving. Fifteen cables in three groups of five each carry the suspension structure and are slung from timber towers built on the tops of the piers at each side. They carry a decking of timber sheets supported on planks upon which the centring proper consisting of ten latticed timber arches. 560ft. span by 11ft. 6in. deep, was built up. The centring trusses are spaced at 3ft. 3in. centres and the total width is 33ft.

Asia

Under the direction of Messrs. Rendel, Palmer, and Tritton, of Westminster, there is now under construction at Calcutta, India, a bridge across the Hooghly River to replace a floating structure which became inadequate to deal with the traffic. The Howrah Bridge, as it is named, will, when finished, have the third largest cantilever span in the world, 1500ft., and is notable on account of the great width, 71ft., of the road it carries, with two 15ft. pathways. The main span will be made up of a suspended span of 564ft. and two cantilever arms, each 468ft. long. The anchor arms will each have a length of 325ft. and the towers will rise to a height of 270ft. above road level. Foundations for the main towers are being put down close by the river banks on each side. The roadway will be slung beneath the main members of the bridge and come down to ground level just beyond the main piers, turning aside under the anchor arms. The work of the contractors, the Cleveland Bridge and Engineering Company, Ltd., of Darlington, was, during the year, concentrated upon the construction of the main piers, which will be supported on concrete monoliths, 180ft. long by 80ft. wide. An accompanying engraving shows an early stage in the sinking of the Howrah monolith through alluvial deposits into the stiff clay which is to be the bearing strata. The steel cutting edge can be clearly seen surmounted by steel shuttering for the concrete, which was built up progressively as the monolith sank. Each of the wells to be seen in the engraving is about 20ft. square. The Howrah pier was plugged in the open, but that at the Calcutta side and the two monoliths on each side for the anchorages were plugged under compressed air. By the end of the year the shafts in each monolith had been plugged with

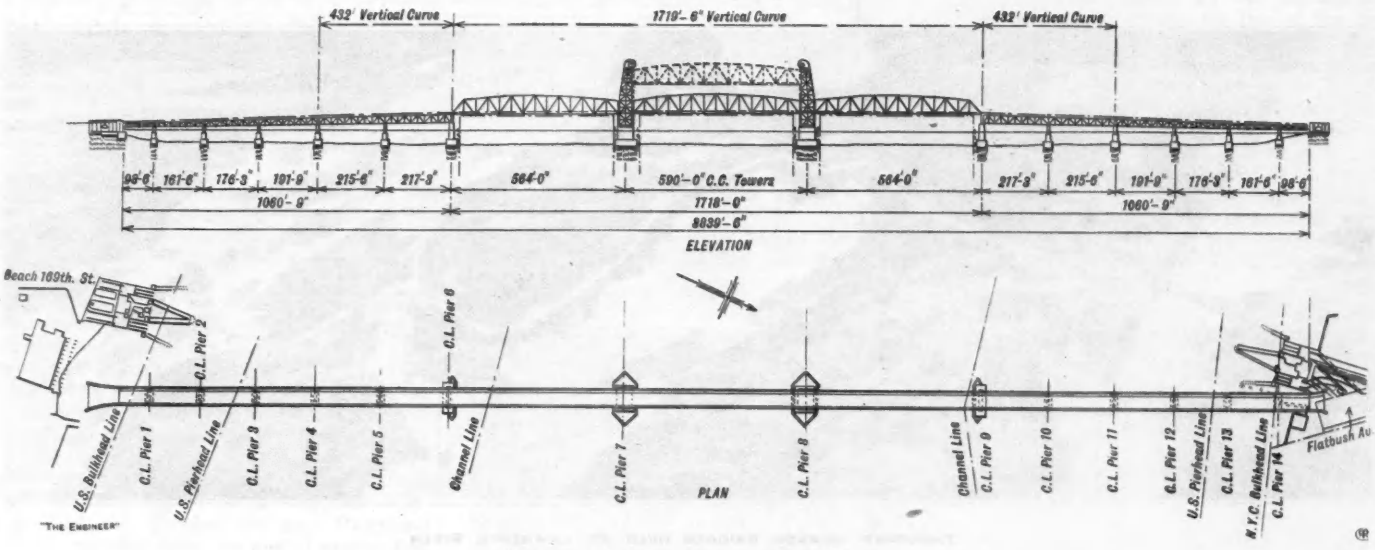


VERRUGAS RAILWAY BRIDGE, PERU

concrete and the erection of the pier caps was begun. Foundations for falsework to carry the anchor arm steel work during erection was also begun. The total weight of steel to go into the bridge will be about 27,000 tons.

Africa

Over the Chirundu gorge of the Zambesi River there was under construction, to the designs of Freeman, Fox and Partners, of Westminster, the Otto Beit suspension bridge to carry a roadway 18ft. wide. The main span is 1050ft. long and the cables hang from towers 125ft. high. The cables



MARINE PARKWAY BRIDGE, NEW YORK

placed outside the stiffening trusses are 35ft. apart, and the trusses, 14ft. deep, are 30ft. apart. The Beit Trustees entrusted the erection of the bridge to Dorman, Long and Co., Ltd., of Middlesbrough, and the same firm is supplying and fabricating the steel. By the end of the year the towers, the cables, and the whole of the steelwork of the bridge had been erected, but riveting had not been begun. It is interesting to note that the whole of the stiffening trusses were erected in twenty-two working days, the weight of steel being 400 tons. An accompanying engraving shows the bridge under construction.

America

In August there was opened in America the Thousand Islands Bridge across the St. Lawrence, connecting Canada and the United States. The work actually consists of several bridges and interconnecting roads making the crossing over the numerous islands in the river channel and the total length is about 8½ miles, of which only 7920ft. is actually over water. On the American side there is first to be crossed a waterway which constitutes one of the main river navigation channels. The structure here consists of a suspension bridge with a central span of 800ft. and two side spans of 350ft. approached by viaducts 1500ft. long on each side. A road thence traces a somewhat sinuous course across Wells Island for a distance of 5 miles to a narrow channel known as the International Rift, which forms the border between Canada and the United States. It is spanned by a masonry rigid-frame arch, 90ft. long. For a further distance of 2 miles the road passes across Hill Island, then reaching the main Canadian structures, illustrated by an engraving in the Supplement. There are here in order a 600ft. continuous truss span with one intermediate pier founded on a convenient rocky islet; a viaduct over Constance Island, 516ft. long; a steel arch span, 348ft. between piers and 388ft. between terminal pylons; a viaduct, 205ft. long over Georgiana Island; and finally a suspension bridge with a central span of 750ft. and side spans of 300ft. over the Canadian navigation channel. The work was designed by Messrs. Robinson and Steinman, of New York, and a number of contractors were engaged during the period of only 15½ months required to find foundations and erect the superstructure. There is little of any particular interest in any of the separate structures, which are of ordinary design. But a new form of connection, invented by Holton D. Robinson, was used for attaching the suspension cables of both suspension bridges to the anchorages. Bars are set in the concrete of the anchorage to correspond in number and arrangement with the strands of the cables. The upper end of each bar is upset and threaded and each strand terminates in a cast steel socket externally threaded to the opposite hand. Connection between the two is made by a turnbuckle, and after the tension has been adjusted the buckles are spot welded at the ends to prevent subsequent rotation.

Another American bridge deserving mention is that spanning Rockaway Inlet between the Brooklyn shore and Rockaway beach near New York. It is known as the Marine Parkway Bridge and consists of fifteen spans of the lengths shown in an accompanying drawing. Its total length is 3839·5ft. In the centre are three through truss spans and the remainder are deck truss spans of the continuous type, consisting on each side of a continuous truss over three spans, another over two spans and the third, 98ft. 6in. long, a single span. The central through truss is arranged for lifting. In its lowered position it gives a clearance of 55ft. and when raised 150ft. The towers are 225ft. high over mean sea level and the lifting truss is supported by eighty 2¾in. wire ropes running over sheaves 15ft. pitch diameter driven by four 200 H.P. electric motors. By the use of a metallic "open grating" roadway the weight of the span was kept down to 2180 tons. The bridge was designed by Messrs. Waddell and Hardesty, of New York, and is illustrated by an engraving in the Supplement.

In the same neighbourhood the Henry Hudson arch bridge in New York was fitted during the year with an upper deck at a cost of 800,000 dollars. The work, provision for which had been made when the bridge was originally erected, was completed in less than eight months. The deck is supported by 14in. H-section 95-lb. columns spliced to the underlying supporting columns of the original arch and spaced at 30ft. centres. The clearance between the upper and lower decks is 16ft.

In Peru there was completed a railway bridge on the Central Railway across the Verrugas Gorge. It carries a single 4ft. 8½in. gauge track and replaces an older bridge which was unsuitable for the loads it was called upon to bear. The bridge, the design of which is shown by an accompanying drawing, is 720ft. long with a central span of 230ft., side spans of 131ft., towers 30ft. wide, and a 66ft. approach span. The steel towers are 79ft. 8½in. high, erected on massive concrete piers. Work upon the bridge was hindered not only by the material at the site, which consists of a kind of conglomerate containing very large boulders that may be loosened at times of heavy rainfall and roll down the slopes of the valley side, but also by a deadly disease carried by a mosquito-like insect.

Aeronautics in 1938

ALTHOUGH aeronautical engineering may be just normal engineering applied to aeronautical problems, it has the special feature that it is so applied in conditions of more than ordinary difficulty by reasons of the complex nature of the stresses that arise in manœuvre and the drastic requirement of economy in weight. As an eminent Oxford professor put it, aeronautical engineering is "ordinary engineering made more difficult." Not a little of that difficulty at the moment is due to the intense pressure, on account of the international situation, for rapid construction. It happens, too, that at the present time technical processes are changing to meet new conditions, and to take advantage of new knowledge. Hence a survey of the year's progress needs to pay regard not only to the methods of the past which have run over into the present period, but to the new methods now in process of adoption, and to do this effectively requires some knowledge of the circumstances in which the present procedure arose, as well as a discussion of the ideas now current in the minds of those in charge of the march of events. Any such review must, however, suffer from the fact that military objectives, of a naturally confidential character, are so bound up in the specifications of the aircraft under construction that even the most purely technical survey of them must be so guarded as not to reveal more than those points of general engineering interest which may fittingly be the subject of discussion in such a journal as THE ENGINEER. There is, nevertheless, as reference to the aeronautical journals of this and other countries will fully show, a considerable degree of publicity allowed on the subject of the scientific and technical advances made in this science, and a review of these is naturally of interest to engineers, not merely to those whose daily task it is to study such matters, but to that much larger group, which, whilst working in other fields, is desirous of following the progress made in this new and very active one. For in the general advance of engineering technique, aeronautics often acts as a spearhead, being driven to do so by the intensity of the aim towards greater efficiency in performance in relation to weight, whilst preserving a reasonable measure of safety against accident. Safety in flight cannot be sought by the time-honoured method of a comfortable addition to dimensions for that would mean extra weight and would itself militate against the very safety that was being sought. Instead, the attack has had to be one in which new materials are found, or in which old ones are prepared in forms having greater endurance than anything known in the past.

Streamlining

Take, for instance, the chief materials of aircraft construction. Initially this construction was composed of a somewhat confused, and certainly complex, combination of wood and wire. The air resistance was high, and gradually the wires became streamlined; this happened long before any idea of streamlining the whole aircraft was dreamed of. In the light of present achievements the speeds of those early days were extraordinarily low; hence the high resistance was not looked on as a grave fault. In fact, it was often felt that increase of performance must depend mainly on

such improvements as might be made in the engine, whereby it would give more power, preferably with but little increase in weight, rather than by doing anything to the form of the airframe. But less than ten years ago it was pointed out by Professor B. M. Jones, of Cambridge, that a very striking increase in performance was obtainable by streamlining the whole aircraft, and although this seemed at the time a difficult thing to achieve, the progress made since has been remarkable. The first difficulty was the old requirement that military machines should carry much of the equipment stowed externally, or stowed in such a way as to make it impossible to give a shipshape form to its container. For example, although bomb shapes were themselves streamlined in form, the external carriers to take them were nothing of the sort and the combination of both, usually in close proximity to fuselage or wing, created an amount of what is known as "interference drag," which added enormously to the drag of the entire machine. This kind of resistance is due to the spaces, through or past which the air must flow, being entirely unsuited to smooth air flow, and creative, in intense degree, of turbulence and eddying motion of an undesirable kind. Until the bad aerodynamic effect of this stowed externally gear (and the same applied to guns and was later found to apply to landing gear) could be minimised or got rid of there was little to be gained by making a streamlined craft of the main structure.

Gradually, however, the requirements for external stowage of such gear were abandoned, and there arrived the modern machine as we know it. The move from the biplane to the monoplane, with consequent avoidance of external struts and wires, was a move in the same sense; the change to the retractable undercarriage; the cowling of the engines; and later of the cockpits; and other such measures all worked in the same sense, until to-day an aeroplane can vie with its rival flier, the albatross, as a fine smooth ship-shaped and graceful form.

Air Flow and Turbulence

Speeds have, naturally, risen as a consequence, and this in turn has led to a study of the air flow over the wings and the best way of avoiding any remaining losses through turbulence. In the year under review this was one of the important objects of study. It is on the upper surface of the wing that the air flow is chiefly important. Over the leading part of that upper surface the flow is what is known as laminar; that is, the air flows past in layers more or less parallel to the wing surface, but thereafter develops a turbulent flow until eventually it tends to break away and leave an eddying wake. The study of this phenomenon needs to be carried out under the difficult conditions of free flight, since in the easier experimentation in wind tunnels there exists a natural turbulence in the air even when no model is present for test. In free air such turbulence does not exist, and it is therefore to full-scale work that the experimenter must appeal, despite the natural difficulties in the way of fitting such delicate apparatus in position without interfering with, and so changing, the very thing one is trying to measure, as well as in using the apparatus in conditions so remote from those of the scientific laboratory. Nevertheless, a lot has been learnt which may prove to have great practical consequence. But though the search is directed by the scientist as a means for increasing knowledge, immediate use is usually found for such knowledge when obtained. Even when the scientist does not himself appreciate the immediate consequence, there are plenty of qualified engineers scrutinising the results as they appear and ready to apply them, either by a direct improvement of constructional features or by a fuller understanding of the conditions of aircraft performance.

All-Metal Construction

The practical consequences of this aerodynamic work have to be considered, of course, in relation to the fundamental materials of construction. The use of metal instead of wood came before the streamlined machine, but once it was realised how greatly improved a performance would result from the use of exceedingly smooth wings (so smooth that the extra drag due to excrescences of one-thousandth of an inch was easily measurable) then the use of metal coverings for wing and fuselage became a desirable substitute for the fabric covering commonly used up to that time. Fabric was not the only covering previously in use, for wooden skins had often been adopted in design; nevertheless, at the present day the all-metal aircraft is much the commonest type. In moving from wood to metal the choice soon proved to be one between steel and dural. Actually the ratio of ultimate strength to density is not very different between these two, nor in point of fact for some woods either. But toughness was certainly gained and modern airframes have a much longer life than their predecessors. The difficulty with a high-density material like steel is that the sections giving the desired strength tend to be thin, and questions of their stability under stresses other than the simplest may provide a very troublesome complication. Moreover, one has to design against mere rough casual usage and the thicker sections of the dural type of structure are a great advantage. They are, moreover, easier to handle in the workshop and although steel in its stainless form is much less liable to corrosion than dural, there are ways of overcoming this difficulty.

The coming of metal construction has not only brought increased toughness and durability, but has led in the case of flying boat hulls to greater ease in the repair of any damage to the skin of the boat due to impact with chance floating *débris*. It does present, however, the problem of guarding against corrosion. That is a problem which is specially important for overseas operation or indeed anywhere in proximity to a coastline. In an island like Britain the coast is never very far away and the problem is one which had to be faced at once. Stainless steel was an obvious way out, but suffered from the disadvantage that although its great strength made up for its higher density, nevertheless the sections to be employed were so much slighter than those of the aluminium alloys, as, apart from the stability difficulties already mentioned, to make construction and repair very much more troublesome. Hence dural, or an alloy of that class, became the most used metal for aircraft use. But dural was unfortunately more liable to corrosion, and even now the efforts to meet this cannot be said to be entirely satisfactory. The anodic treatment discovered by the researches carried out under the Department of Scientific and Industrial Research was very useful in affording protection, provided that the parts were not worked upon afterwards; but sometimes they had to be cut or riveted and this brought difficulties of a character easily imagined in its train. Perhaps the most popular variation in use to-day is the sandwich made up of a dural core with a thin layer of pure aluminium on each side. Really pure aluminium is little liable to corrosion, and the sandwich system giving the material known as "Alclad"—was found excellent. It was first used in America, but is now in wide use in the whole world.

The Use of Wood

None the less, there arose during the year under review an unmistakeable tendency to reconsider the possible use of wood for construction, though not in the way in which it was used formerly. This is partly due to the success of that other sandwich made of a centre of some light wood like balsa, with a plywood covering on each side. The purpose of this form of sandwich is not the avoidance of corrosion but the building up of a stiff composite in which the centre part acts merely as a spacing piece between the stress-taking skins, or a means of taking up some of the shear stress. Plywood itself has greatly gained in popularity in recent times because of the good average of uniformity due to the use of thin plies and the greater reliability of the water-resistant synthetic resin cements now used as the binding material. Usually the plywood is compressed to a substantial pressure and this improves both hardness and strength; indeed, in the highly compressed woods the density may run as high as twice that of the natural timber. It is seen at its best perhaps in the hard wooden socketing piece in the modern controllable pitch wooden airscrews. In these the central boss and its mechanism must be of metal, but it is best for the sake of weight saving, that the blade should be of a light natural wood. The problem is how to attach the one to the other in a way which will resist the enormous centrifugal forces which arise when the airscrew is rotating fast. Here the compressed impregnated wood is invaluable, for it is easily fashioned to screw into the metal hub sockets whilst being readily scarfed at the other end to the light blade. The whole is a triumph of ingenuity and is incidentally a handsome piece of work to look at.

The Use of Plastics

Whether, and if so, how far, compressed impregnated wood will be used in the future in aircraft construction is one of the problems of the moment. The plastic itself needs some form of reinforcement before it can be employed for stressed parts and other forms of cellulose than wood are being tried. Cotton thread—with its remarkable ratio of strength to density—has been tried, and an alternative also under test is a reinforcement—if so it can be termed—of cellulose in other less familiar forms. These give quite good ratios of strength to density and are often satisfactory, too, as regards shear strength. The main difficulty in the way of using them for the more important and highly stressed parts of an aeroplane is the large and expensive presses they require, and in turn the large number of such parts that must be made to render the provision of the presses an economical proposition measured in over all man-hours. One hears of attempts in this direction being made in several countries, but little is published of the success that has—or has not—been attained. Rapidity of construction would seem to be one of the advantages of the method—once the likelihood of any change of design had been eliminated. But aircraft design changes so rapidly in these days that there would be some danger in any rapid degree of standardisation.

The wing loading in particular shows every sign of rising even beyond the limit so far reached, which itself has more than doubled during the post-war period. Taking five typical existing transport aeroplanes, American, German, and British, the wing loadings lie between 20 lb. and 30 lb. per square foot, and mainly near the higher limit. Loadings of 40 lb. or even 50 lb. are now freely discussed as possibilities, but such developments need close watching as the control forces which the pilot has to exert tend to grow alarmingly at the same time. Landing speeds also rise with higher loading, and this makes the aerodrome difficulty even greater than it now is.

Speed and Range

We are, as it happens, rather rapidly approaching the natural limit to rising speeds and in the future it may be that adherence to a particular design will be less likely to be an invitation to rapid obsolescence than it is at present. The speeds of which modern aeroplanes are capable show every sign of rising even beyond their present level, and the question may naturally be asked how far this tendency will continue. As it happens, there is a definite limit in this direction. The world's record speed stands at present at 441 miles an hour. It is most unlikely to rise a great deal beyond this figure since by the time the speed approaches 600 miles an hour the air drag forces opposing the motion will have entered on an entirely new *régime*. At such speeds the air passing over the upper surface of the wing will be very close to the velocity of sound, and when that happens the resistance rises very suddenly and very steeply, so steeply that no engine power in sight could possibly balance the forces opposing motion. The tendency in this direction begins at an even lower figure and it is very doubtful whether future speeds, though they may exceed 500 miles an hour, will touch 600. For to do this an entirely new form of prime mover would have to be invented and no such invention is in sight in any form in the least practical. Increase in range is likely enough—the longest distance so far flown in one flight is the record obtained in 1938 by two British Wellesley machines of 7162 miles between Egypt and Australia, beating handsomely the previous Russian record by several hundred miles. What is needed for further advance is a lightening of structure weight so that more fuel can be carried within a safe total loading. Advance in height—or ceiling—depends on this same factor, as well as upon the possibility of maintaining engine power at even greater heights than at present. The present record, attained this year, stands to the credit of the Italian aviator, Lieut.-Colonel Pezzi, at 56,000ft.

Besides the mechanical limits there are also the limits imposed by the endurance of the human body, but these have so far been overcome except as regards manœuvre stresses where high acceleration figures affect the blood supply to the brain and upset the pilot's vision—and if persisted in will injure his body internally.

Engines

Engines for aircraft change their design much less rapidly than the airframe, and this is natural for we are here dealing with a much more mechanically developed mechanism in which the progress, though steady, is not sensational. Engine powers are rising steadily and it is difficult

to see where the limit will come. Some years ago Ricardo forecast that the bottle-neck of engine development would prove to be the exhaust valve, since the greater powers demanded tended to put higher and higher duty on that already exceedingly overworked part. As is well known, the Bristol Company especially has been remarkably successful in developing a form of sleeve valve to replace the poppet, and in this way to widen greatly the bottle-neck which has so far restricted the width of possible advance. As it happens, the use of the sleeve valve also greatly simplifies the general design of the engine, cuts the number of separate parts in half whilst enabling higher compression ratios to be used with a corresponding increase in power output. This gives greater opportunity for the use of those newly developed fuels which permit higher and higher compressions to be used without the risk of detonation. It is the continued improvements in the qualities of motor spirit which make it so difficult for the compression-ignition engine to hold its own despite the enormous advantage it has of lessened fire risk.

The availability of more powerful engines, of special fuels and of controllable pitch airscrews has made the take-off problem less difficult, and the many designs of wing flap are efforts in the same direction. The combination of them all may avoid for the moment the use on any large scale of catapult propulsion or of re-fuelling in the air. But operators are Oliver Twists in always asking for something more, and it may be that the self-contained take-off will not continue to be possible for really heavily laden machines.

Gyroplanes

The use of rotating wings in aircraft has suffered from the inherent difficulty of producing a streamlined craft. The supports for the windmills, and the arrangements for giving a mechanical drive to them, are difficult to house in a form which reduces air resistance. Moreover, the special forms of undercarriage normally used in gyroplanes are of a type difficult to retract into the body. Nevertheless, there are several firms engaged in this development and the results obtained are quite promising. Rotating wing aircraft are essentially special-purpose machines, and it is unlikely that they will ever rival the fixed wing type in respect of speed, though for safe and easy landings in restricted areas, or in time of fog or other conditions of low visibility, they are incomparably better, and this valuable feature goes far to balance the higher cost of construction.

Landplanes or Flying Boats

One of the outstanding questions of the year is whether the large aircraft of the immediate future will be flying boats or landplanes. At one time the boat type suffered from high structure weight and low performance, but these disabilities have already been removed. Large landplanes have difficulties of their own. Their very weight causes difficulties in regard to landing on all but the hardest aerodrome surfaces, and if the wheel size is increased so as to diminish the intensity of the pressure on the ground, the weight of the landing gear goes up alarmingly, whilst the difficulty of finding space in which to retract it also increases. On the other hand, the larger the boat the smaller relatively are the irregularities of the water surface on which it has to alight, and the larger therefore becomes in effect the water area available for landing. It certainly seems as though the large aircraft of the future will be of the boat type. This will, without doubt, be a gain from the point of view of the passenger, for the making of ocean crossings in landplanes cannot be expected ever to become popular.

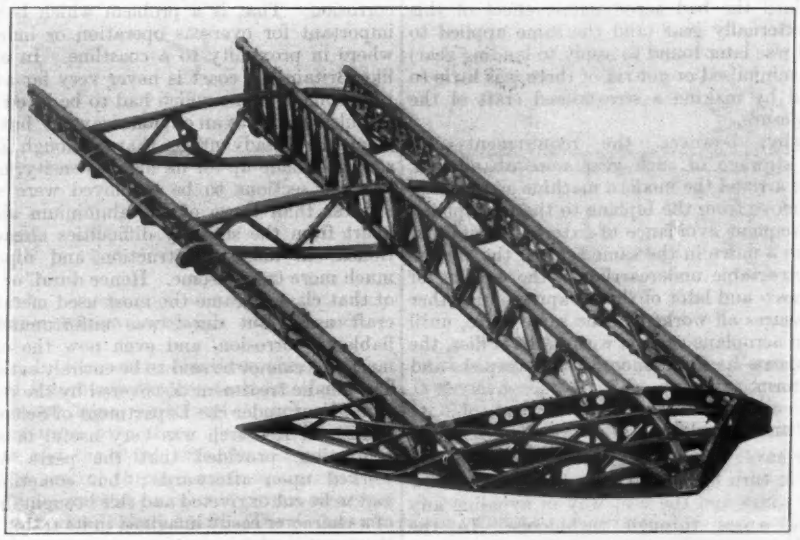
SOME TYPICAL BRITISH AIRCRAFT.

General Aircraft, Ltd.—The "Cygnet" machine illustrated in the Supplement is claimed by its makers, General Aircraft, Ltd., of Feltham, Middlesex, to be the only all-metal, stressed-skin, light civil aeroplane as yet being made in this country. It is designed to carry two, in side-by-side seats, and is suitable for either training or touring purposes. In the production version the machine will be fitted with a tricycle undercarriage, which is claimed greatly to reduce the skill required for landing and taking-off, and with a double ruddered tail, which will increase the directional and fore-and-aft stability to an extent that will permit flight with hands and feet off the controls at any throttle opening. The machine is a low-wing cantilever monoplane, having the centre section integral with the forward portion of the fuselage. The wings and fuselage are covered with a skin of smooth sheet metal. The power plant consists of a 130 H.P. four-cylinder "Gipsy Major" engine, driving a fixed pitch airscrew. Alternatively, the machine may be fitted with a "Menasco" supercharged engine driving a controllable pitch airscrew. The maximum speed at sea level is 148 m.p.h., and the range 600 miles.

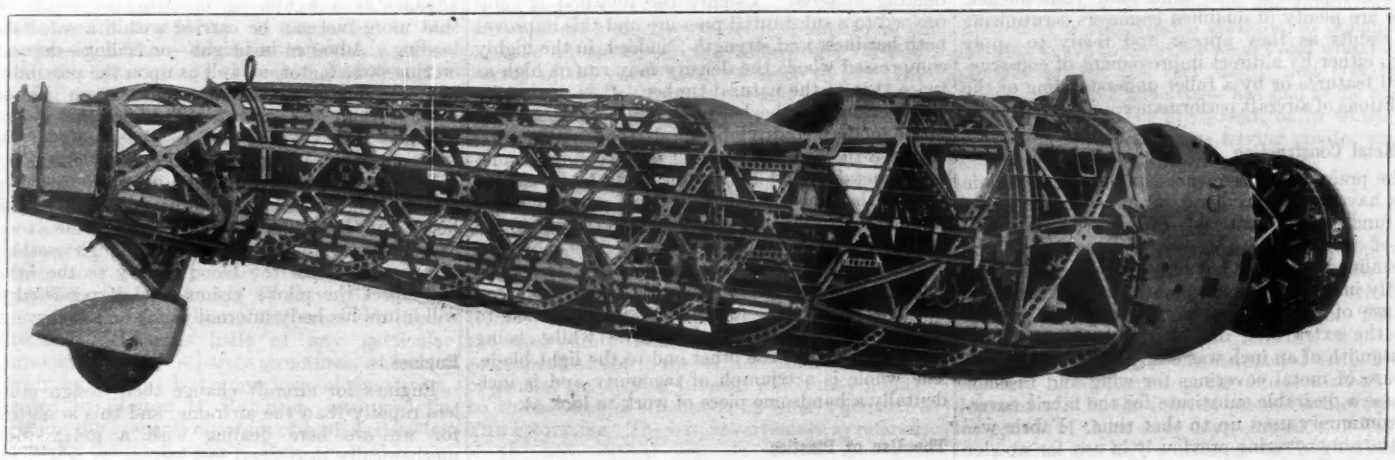
The same company is now building a new type of machine, the "Cagnet," which is being specially designed for the use of the Civil Air Guard. This machine will be a two-seater low-wing monoplane, and will be driven by a 50 H.P. "Pixie" air-cooled engine, coupled to a pusher airscrew. The construction will be mainly of wood.

Phillips and Powis Aircraft, Ltd.—The Miles "Magister" two-seater low-wing cantilever monoplane was made in large numbers during the year by Phillips and Powis Aircraft, Ltd., of Reading, for initial training purposes in the Royal and other air forces. It is of wooden construction with plywood coverings to the wings and fuselage. It is equipped with dual control and can be flown from either cockpit. A wide track cantilever undercarriage is fitted and split trailing edge flaps are provided to improve the gliding angle and the landing speed. The engine is a "Gipsy Major" and drives a wooden airscrew. It is mounted on an independent detachable steel tubular structure fixed to the four fuselage longerons by a pin at each joint. The machine has a maximum speed of 145 m.p.h. and a range of 400 miles. The landing speed is only 45 m.p.h. A detail feature in the design of the machine is the fact that the trailing edge flaps are operated by a vacuum system. The vacuum is obtained from the engine induction manifold, a pipe from which runs to a storage reservoir. From this reservoir vacuum is applied to one end or the other of a ram coupled to the flaps which may be opened or closed—or set in any partially opened position—by the operation of a valve under the pilot's control.

Handley Page, Ltd.—During 1937 Handley Page, Ltd., began and completed a large order for "Harrow" bombers, the number produced during that year being sufficient to equip five complete squadrons, with ample reserves. We illustrated the "Harrow" design in our issue of January 1st, 1937. The same quantity production methods are now being applied in connection with the manufacture of the "Hampden" type of aircraft, illustrated in the Supplement. The "Hampden" is a high performance medium bomber. Although the "Hampden" is smaller than the "Harrow," it is reported to be capable of carrying a heavier bomb load for a greater distance at a higher speed. It is driven by two "Pegasus" engines. The machine has a span of 69ft. 4in., a length of 52ft. 5in., and a height of 14ft. 4in. The "Hampden" is now being produced in large numbers in many different places. It is the aeroplane selected to be built in Canada for the Royal Air Force and in a modified version, known as the "Hereford" and equipped with a Napier "Dagger" engine, it is being built at the newly formed Short and Harland factory at



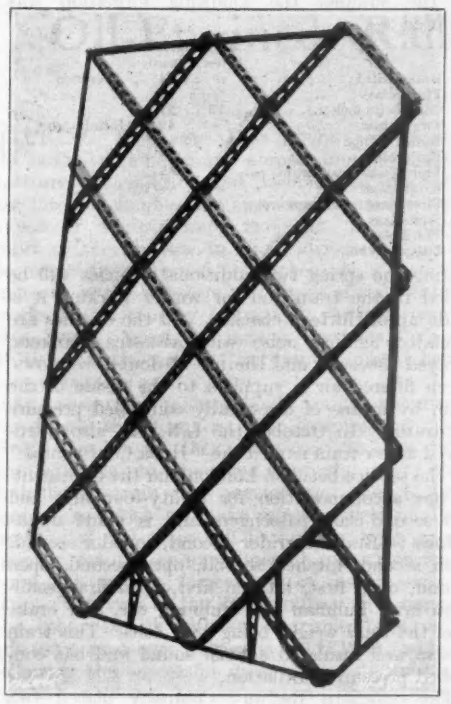
GEODETIC WING FRAME



FUSELAGE CONSTRUCTED ON GEODETIC PRINCIPLES

Belfast. All the companies building it have been provided by the originators of the design with full particulars of the "split-component" method of production introduced and developed at Cricklewood during the execution of the "Harrow" contract.

Short Brothers, Ltd.—The year witnessed the completion by Short Brothers, Ltd., of the order for thirty-one "Empire" flying boats placed with the firm by Imperial Airways, Ltd. A further order for eight additional boats was received. These boats are strengthened to permit a certificate of airworthiness to be obtained for an all-up weight of 53,000 lb. The take-off weight is fixed at 46,000 lb., the remaining 7000 lb. being added as fuel, by means of Sir Alan Cobham's flight refuelling scheme, after the machine is in the air. Three of these new boats are now in service. Some of the eight, it is intended, will be used to operate a North Atlantic air service in the spring of this



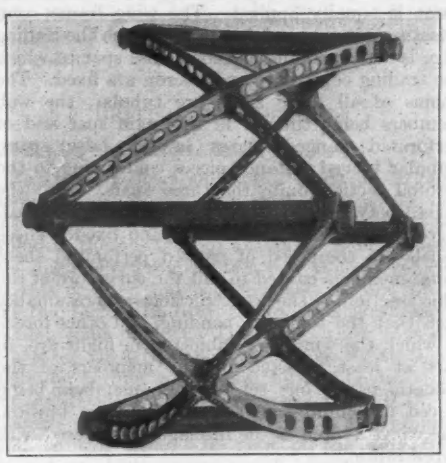
GEODETIC PANEL FOR WING

year, and others will probably be employed on a service between Australia and New Zealand. Three new flying boats of increased size and performance were begun for Imperial Airways. These boats will be similar to the "Empire" type, but their all-up weight will be increased to 73,000 lb. They will be driven by four Bristol "Hercules" engines. During the year the Mayo composite aircraft satisfactorily completed all tests and subsequently the upper component "Mercury" carried out three notable flights, each being begun with the aid of the lower component "Maia." On the first of these flights the "Mercury" flew non-stop from Foynes to Montreal. On the second it obtained the long-distance seaplane record by flying from Dundee to the Orange River. On the third it carried 1 ton of mails from Southampton non-stop to Alexandria in 14½ hours. The "Mercury" was built primarily to establish the practicability of the principle of mid-air separation. As the success of that principle has been proved designs have now been begun for a landplane to take full advantage of the Mayo composite method of launching. Another interesting order placed with the firm during the year was one received from the Air Ministry for three civil landplanes for long-range duties. Two of these machines will operate at 10,000ft. and the third will be designed with a supercharged cabin to operate at 25,000ft., the pressure maintained in the cabin being that corresponding to an altitude of about 8000ft. These machines will have an all-up weight of about 71,000 lb., and will be driven by "Hercules" engines, the engines of the high-altitude machine being fitted with an exhaust turbo-blower. They have been designed for a range of 3000 miles against a head wind of 30 m.p.h., and will carry a payload and crew totalling 8800 lb. The mean cruising speeds will be 245 m.p.h. and 275 m.p.h. for the low and high-altitude versions respectively.

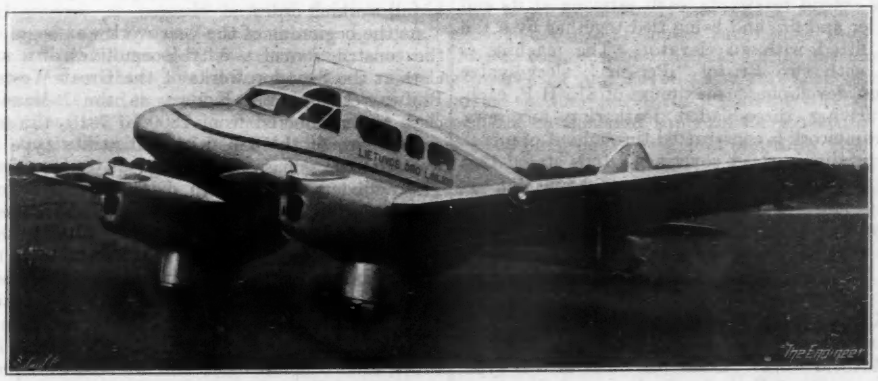
The "Sunderland" flying boat illustrated in the Supplement was in steady production during the year. This boat is comparable in size with the "Empire" type, but is designed to meet Service requirements. Several overseas squadrons are now equipped with it. It has a span of about 113ft., a length of 85ft., and a height of about 32ft. It weighs when empty 28,290 lb., and when carrying 1570 gallons of petrol, 92 gallons of oil, its service load and its crew, it has an all-up weight of 45,700 lb. With an overload of petrol and oil its all-up weight is increased to 49,870 lb. It has a maximum speed of 210 m.p.h. at 6250ft., a normal range in still air of 1670 sea miles, and an overload range of 2500 sea miles.

Vickers-Armstrongs, Ltd.—The Vickers-Wallis "geodetic" system of airframe construction was first applied in the "Wellesley" single-engined long-range bomber, torpedo carrier, or general-purpose machine which we illustrated in our issue of January 10th, 1936, and again in our issue of January 7th, 1938. Subsequently, it was applied to the "Wellington" twin-engined bomber illustrated in our issue of January 1st, 1937. Until quite recently details of the geodetic system of construction have been closely concealed. Even now secrecy in certain respects is preserved, but it is possible to give some idea of the general principle employed.

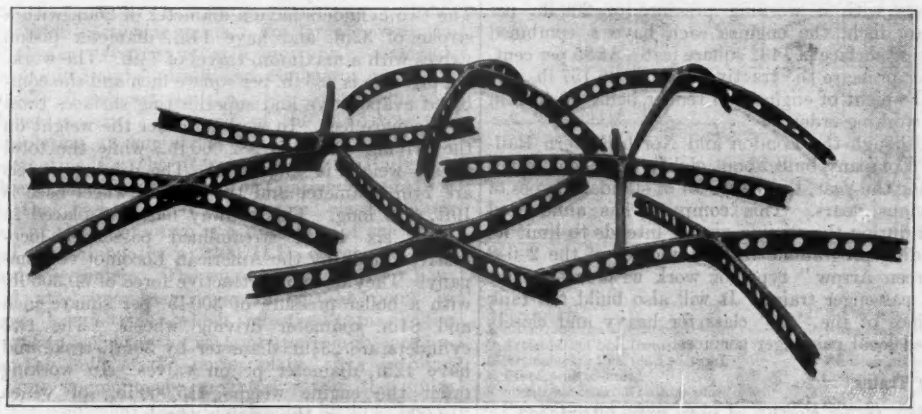
The geodetic system may be considered as an alternative to the stressed-skin method of construction. With the stressed-skin system the aspect ratio of a monoplane cannot be made much greater than 6 or 7 without resort to a relatively low factor of safety or without incurring a very heavy structural weight. With the geodetic system an aspect ratio of 9 or 10 can, it is claimed, be adopted without incurring either of these penalties. With this large aspect ratio the aerodynamic efficiency is proportionately improved. It is stated that a geodetic machine can carry heavier loads faster, farther, and higher than a comparable machine of the same power constructed on a different principle, and that a geodetic fuselage is only two-thirds of the weight of an ordinary fuselage, is more than twice as strong flexurally and nearly twice as stiff in torsion. The name "Geodetic" has been applied to the form of construction evolved by Mr. B. N. Wallis, because the bracing members of the structure are placed in the surface of the body along the lines in which the principal stresses set up in flight are known to act. These lines follow the shortest path from point to point and therefore conform to the definition of a geodetic line. The resultant structure, as will be gathered from the photographs reproduced herewith, resembles basket work. The geodetic members are disposed diagonally in the form of two opposite handed spirals girdling the structure. At every nodal point—that is, at every point at which the two geodetic spirals cross each other—the bracing members are firmly secured to one another. The arrangement is such that under any combination of external forces the members of one spiral are subjected to compression and those of the other spiral to tension.



SECTION OF FUSELAGE



"Q"6" PASSENGER AIRCRAFT—PERCIVAL



GEODETIC MEMBERS READY FOR RIVETING TO LONGERON SECTIONS

In one of the accompanying engravings we illustrate a group of geodetic members as assembled before being riveted to the longeron sections. Each such member, it will be noticed, is composed of four curved arms assembled by means of a central union piece into the form of a cross, the curvature of the arms varying to suit the desired elliptical cross section of the fuselage. Considering any one member as consisting of two curved beams crossing each other at right angles at their midpoints, it is argued that if one beam is subjected to compression its curvature will tend to increase, while if the other is simultaneously subjected to tension its curvature will tend to decrease. At the nodal, or crossing, point the force applied by either beam to the other maintains the beams in equilibrium without change of curvature. It is claimed for this construction that the required streamline shape can be obtained without the use of additional fairings or falsework and that with a very light gauge of

metal it is possible to obtain great stiffness.

It will be gathered from another of our engravings that the fuselage is composed of a number of sections, each consisting of four curved crosses riveted to four portions of the longerons. These fuselage sections are subsequently joined together by means of screwed fittings.

While the application of the geodetic principle is fairly clear in the case of the fuselage, we have some difficulty in understanding its application to the structure of the wings, to which structure the name is equally applied. The wing frame comprises a main spar, a false spar to which the leading edge is attached, and a second false spar to which the trailing edge, flap, and aileron are fixed. The booms of all three spars are tubular, the web members being tubular in the main spar and of perforated flanged plates in the false spars. Tubular braced distance pieces conforming to the aerofoil section unite the three spars. Into the spaces between the spars and the distance pieces "geodetic panels" are inserted and fixed. These panels are composed of crossed perforated sheet metal members curved to suit the curvature of the wing section. The construction is presumably such that the torsional, bending, and other forces to which the wings are subjected in flight are, in part at least, resisted by the members of the geodetic panel, one set of these members being placed in compression and the other in tension. The wings as well as the fuselage are covered with doped fabric.

Cunliffe-Owen Aircraft, Ltd.—At the Southampton Airport a new factory occupying a site of about 6½ acres is being erected for Cunliffe-Owen Aircraft, Ltd., and is expected to be completed at the end of this month. The company is manufacturing the Burnelli "Flying Wing" aircraft, of which we published particulars and illustrations in our issue of May 21st, 1937. The "Flying Wing" is a twin-engined monoplane distinguished by the fact that it has no fuselage in the ordinary sense. The crew and passengers are accommodated in what may be described as a central enlargement of the wing section. From this aerofoil cabin two booms extend rearwards, each carrying at its end a rudder and fin, and being tied together by a tail plane fitted with an elevator. The machine is fitted with two Bristol "Perseus" sleeve-valve engines, developing a maximum of 815 H.P. each, and driving three-bladed feathering airscrews. The framework is constructed throughout of metal, with duralumin sheet coverings. It is stated that under maximum speed conditions about 90 per cent. of the total lift is derived from the aerofoil section central cabin portion. At lower speeds the wings supply the bulk of the lift.

De Havilland Aircraft Company.—The de Havilland "Albatross" transcontinental passenger liner—or in its alternative form as an intercontinental mail carrier—was put into quantity production at the Hatfield works. Some machines of this type, known as the "Frobisher" class, are already in service with Imperial Airways. A new twelve-seventeen passenger liner, known as the "Flamingo," was tested in the air during the last week of the year and will be produced in quantity in the coming months. The "Moth Minor" is another new production of the company's. It is a two-seater training and private touring machine with a cruising speed of over 100 m.p.h. Other types of machine produced by the firm in large numbers were the "Dragon Rapide" twin-engined branch-liner, the "Don" intercommunication machine, the "Tiger Moth" trainer, and the "Queen Bee" radio-controlled target aircraft. The Stag Lane, Edgware, engine factory was considerably enlarged and is now producing six types of "Gipsy" engine. The Edgware airscrew factory is now producing constant-speed controllable pitch airscrews for engines ranging from 150 H.P. upwards to the largest made. Large sums of money were expended on providing the equipment required for the production of the latest design of "Hydromatic," fully-feathering, constant-speed airscrew, deliveries of which will be made this year. On the experimental and research side particular interest attaches to the development of plastics at Hatfield. In conjunction with the Bakelite Company plastic airscrew blades were produced and are now being tested in flight. In addition, experiments are in progress on the production in plastic material of spars, ribs, and stressed-skin structures.

Percival Aircraft.—At the Luton works of Percival Aircraft, Ltd., there was full activity on the production of "Vega Gull" and "Gull" aircraft and of the new "Q 6" type illustrated herewith. The "Q 6" is designed to carry six or seven passengers in a sound-proof cabin and can be adapted for military duties such as reconnaissance, photography, instruction, or ambulance duties. The framework of the wings and fuselage is of wooden construction and is covered with fabric. The undercarriage units may be either fixed and faired in with streamline covers, as illustrated or be arranged to be retracted into the engine nacelles. The power plant consists of two 205 H.P. "Gipsy Six" engines driving controllable pitch or constant-speed airscrews. The machine has a loaded weight of 5500 lb. and a maximum sea level speed of 195 m.p.h. The cruising speed at 7000ft. with a retractable undercarriage is 181 m.p.h. and with a fixed undercarriage 172 m.p.h.

Locomotives and Trains in 1938

DURING the past year there was little work of an outstanding nature in connection with locomotives or rolling stock on the British railways. The new engines which were built repeat, or follow closely, the design of earlier types. On the London, Midland and Scottish Railway the four-cylinder 4–6–2 "Princess Coronation" class engines have proved very successful in service, and in May last it was decided to build ten more of a similar type in the Crewe workshops of the company. Known as the "Duchess" series, five of these engines are streamlined and the remainder are built in the standard form. Only minor variations in design from the original "Coronation" engines were incorporated in the new locomotives, the leading particulars of which are as follows:—Cylinders, 16½in. diameter by 28in. stroke; boiler pressure, 250 lb. per square inch; total evaporative heating surface, 2807 square feet; superheater heating surface, 856 square feet; grate area, 50 square feet; driving wheels, 6ft. 9in. diameter; wheel base, 37ft.; weight in working order, 105 tons 5 cwt.; and tractive effort, 40,000 lb. at 85 per cent. boiler pressure. The streamlined type of engines are slightly heavier, weighing 108 tons 2 cwt., the principal increase in weight being upon the trailing axle, which carries 16 tons 16 cwt. in the non-streamlined, and 18 tons 10 cwt. in the streamlined engine. The tender, which takes 4000 gallons of water and 10 tons of coal, weighs 56 tons 7 cwt. in full working order.

At the beginning of the year work was begun on the construction of twenty locomotives of a new class at the Swindon works of the Great Western Railway Company. Known as the "Manor" class and numbered from 7800 to 7819, the new engines are of the 4–6–0 general utility type for work in express passenger and goods train services. The cylinders are 18in. in diameter and have a stroke of 30in. The bogie wheels have a diameter of 3ft. and the coupled wheels 5ft. 8in. With a working pressure of 225 lb. per square inch the boiler has a barrel 12ft. 6in. long, and an outside diameter of 4ft. 7⅛in. to 5ft. 3in. The grate area is 22·1 square feet and the heating surfaces are as follows:—Superheater, 190 square feet; fire tubes, 1285·5 square feet; and fire-box, 140 square feet. In full working order the engines weigh 68 tons 18 cwt. and have a tractive effort of 27,340 lb. The coupled wheel base is 14ft. 9in. long and the overall length of the engine is 36ft. 8in.

With the steadily increasing mileage of electrified lines there has been little new work in connection with steam locomotives undertaken by the Southern Railway Company for some time past, but in February last the first of ten goods locomotives of a new class was completed at Eastleigh. Of the 0–6–0 type and designed by Mr. R. E. L. Maunsell, they are of a general utility design, being fitted for passenger train working when required. The 19in. diameter by 26in. stroke inside cylinders have long travel 10in. diameter piston valves, operated by Stephenson valve motion through rocking levers. Fitted with Belpaire pattern boilers with a working pressure of 200 lb. per square inch, the engines each have a combined heating surface of 1432 square feet. At 85 per cent. boiler pressure the tractive effort is 26,157 lb., the total weight of engine and tender being 90 tons in full working order.

Although the London and North-Eastern Railway Company built about eighty new locomotives during the year, they were all of standard types of previous years. This company has announced that during the coming year it intends to limit its building programme to fifty engines of the 2–6–2 "Green Arrow" type for work with fast freight and passenger trains. It will also build ten tank engines of the "V" class for heavy and closely timed local passenger services.

New Trains

New trains worthy of note were introduced by both the London and North-Eastern Railway Company and the Southern Railway Company.

For the "Flying Scotsman" service two new trains were completed by the L.N.E.R. to the designs of Sir Nigel Gresley. The design was influenced by the fact that trains are divided at Edinburgh to serve Glasgow, Perth, and Aberdeen. In the summer the following formation was adopted:—

	Passengers. First.	Third.	
Brake third	—	24	Aberdeen
Third class	—	42	,,
Composite locker	12	21	,,
Third class	—	42	Edinburgh
Buffet lounge	20	—	,,
Third class	—	42	,,
Third-class restaurant car	—	42	,,
Kitchen car	—	—	,,
First-class restaurant car	36	—	,,
First class	24	—	,,
Third class	—	42	,,
Luggage van	—	—	,,

During the spring two additional vehicles will be added to the train and for winter working it is made up of thirteen coaches. All the coaches are insulated against noise with absestos blankets, sprayed asbestos, and the use of double windows. Fresh filtered air is supplied to the inside of the train by means of electrically controlled pressure apparatus. In October the L.N.E.R. also introduced a new train named the "Hook Continental" for the service between London and the Continent. It has accommodation for eighty-four first and 240 second-class passengers and is made up as follows:—Brake corridor second, corridor second, open second, kitchen second, open second, open second, open first, kitchen first, open first, semi-open first, Pullman car, Pullman car, and brake van, the total weight being 484½ tons. This train is also well insulated against sound and has controlled pressure ventilation.

The Southern Railway Company placed two trains of renovated vehicles in service on its London, Bournemouth, and Weymouth summer service. They consist of eleven coaches and have accommodation for 102 first and 408 third-class passengers.

Abroad

In Canada the most interesting engines built during the year were ten new 2–10–4 locomotives for the Canadian Pacific Railway. Known as the "T.1.B." class, the new engines are a modified design of twenty engines of the same general type built in 1929. They are reported to be capable of hauling trains weighing 1050 tons up gradients of 1 in 45, or the equivalent of 12,000 tons on the level. The cylinders are 23in. diameter by 32in. stroke and the working pressure is 285 lb. per square inch. Each engine weighs about 200 tons and has a tractive effort of 90,000 lb.

Amongst the number of large engines placed in service in the United States during the year were thirty 4–8–4 type locomotives, built for the Chicago, Milwaukee, St. Paul, and Pacific Railroad by the Baldwin Locomotive Works. Designed primarily for freight service, these engines are each capable of developing a tractive force of 70,800 lb. The two cylinders have a diameter of 26in. with a stroke of 32in. and have 14in. diameter piston valves with a maximum travel of 7½in. The working pressure is 285 lb. per square inch and the combined evaporative and superheating surfaces total 7845 square feet. In working order the weight on the driving wheels is 282,000 lb., while the total engine weight is 490,450 lb. The driving wheels are 74in. diameter and the driving wheel base is 19ft. 3in. long. This railway has also placed in service six 4–6–4 streamlined passenger locomotives made by the American Locomotive Company. They develop a tractive force of 50,300 lb. with a boiler pressure of 300 lb. per square inch and 84in. diameter driving wheels. The two cylinders are 23½in. diameter by 30in. stroke and have 12in. diameter piston valves. In working order the engine weighs 415,000 lb., of which 216,000 lb. is on the driving wheels.

A number of new engines have been supplied to

the Atchison, Topeka, and Santa Fe Railroad by the Baldwin Locomotive Works. A particular point of interest is that a number of the parts of eleven 4–8–4 passenger and ten 2–10–4 freight engines are interchangeable. The passenger engines work in mountainous country, where gradients of 3½ per cent. are encountered and they have a tractive force of 66,000 lb. They have a working pressure of 300 lb. per square inch, driving wheels 80in. diameter, two cylinders 28in. diameter by 32in. stroke, and in full working order weigh 499,600 lb. The freight locomotives are a development of an earlier type built in 1930. Five of them are oil and five coal-fired, the former weighing 538,520 lb. and the latter 545,260 lb. The two cylinders are 30in. diameter by 34in. stroke, and are fitted with 15in. diameter piston valves actuated by Walschaerts valve gear. The boiler pressure is 310 lb. per square inch and the engines have a rated tractive force of 93,000 lb.

Ten 4–6–4 heavy passenger locomotives built by the American Locomotive Company have been placed in service by the Chicago and North-Western Railroad between Chicago and Omaha. These engines have a tractive force of 55,000 lb. and weigh 412,000 lb., of which 216,000 lb. is on the driving wheels. The boilers have a combined evaporative and superheating surface of 5863 square feet and carry a working pressure of 300 lb. per square inch. All of the engines have two cylinders, 25in. diameter by 29in. stroke, with piston valves actuated by Baker gear. Seven of the engines have 12in. diameter piston valves, the maximum valve travel is 7¼in. The driving wheels are 84in. diameter and the driving wheel base is 14ft. 8in. long.

Oil-Engined Rail Traction in 1938

No. I

DURING the year 1938 there was much activity at home and abroad amongst manufacturers of railcars and locomotives propelled by internal combustion engines, and many new types of vehicle were evolved. Regrettably, most of the impetus in this movement appears to come from abroad, but there is a notable increase in the numbers and types of rail vehicle made in this country for export, particularly for the South American railway systems, where British manufacturers of railway equipment have always found a good market.

Of passenger railcars and trains manufactured in this country, for service on the British railways, there appears to be but one example to the credit of the year, the articulated train for service on the L.M.S. system, to which we make reference below. The working of this train will be followed with great interest, for it is an experimental unit which may point the way to further use of fast passenger units of this type on the British railways. Amongst the other British railway companies, the only one using passenger railcars is the G.W.R., which, following the successful operation of its existing eighteen vehicles, has ordered, as noted below, twenty more units, to make a total of thirty-eight on the company's lines. Details of the new cars are not yet available, and it is not expected that any will be delivered until well into the present year, but we understand that, although the general design will follow the existing successful one, the new railcars will be capable of being operated in multiple, together with trailer coaches. The Great Northern Railway of Ireland successfully put into service a new design of articulated passenger railcar, which is notable for the arrangement of the central power bogie. Brief reference to this design is also made in the following article.

On the industrial and shunting locomotive side there was an increased demand, one of the largest orders being for twenty locomotives for the L.M.S., some of which have now been delivered. Several of the works shunting locomotives produced during 1937, particularly certain special designs suitable for use in explosives plants and other dangerous areas, have proved successful and repeat orders were obtained last year.

Reviewing the situation generally, it would appear that many of the railways of the world have benefited by their early experiences in the operation of internal combustion engined vehicles and have evolved designs which are suitable for their particular needs. For large powers the oil-electric system is still universal, although mechanical and hydraulic transmissions are being rapidly developed with a view to transmitting higher powers. An event of the year was the completion of successful trials by a 4400 H.P. locomotive for the Roumanian State Railways. This locomotive is typical of Continental practice in the high-powered oil-electric class. Each half of the locomotive is a duplicate of the other and accommodates a 2200 H.P. oil engine with twelve cylinders. The engines run at 700 r.p.m. and are supercharged—an important point in large locomotives, which effectively raises the power-to-weight ratio, without appreciably increasing the bulk of the power plant, thus enabling a large engine to be mounted within the limits of the somewhat small Continental loading gauge. American practice with high-powered locomotives is in direct contrast, for unsupercharged, two-stroke engines of 900–1200 H.P. are more or less standardised, and from three to six engines are used for locomotives up to 3000 H.P. or more. This arrangement, however, may lead to complication, as the numbers of cylinders and driving sets necessary may be as many as three times the corresponding number for the Continental locomotive. This disadvantage is offset to some measure by the ease with which a complete power set can be shut down for attention *en route*. On account of the great distances covered by the American trains, this feature is of considerable importance.

For lighter duties, much attention has been given to control systems for the multiple-unit control of railcars, and several successful systems have been evolved which eliminate many of the disadvantages as regards lack of flexibility of mechanical and hydraulic transmission systems. After an initial period of experiment, several railway systems have settled down to standardised requirements, and it would appear that substantial production cost economies can be effected by such standardisation as is possible. An example of this tendency is to be found in the 108 railcars delivered by a British concern to four different South American railways; these vehicles embody standard power transmission, and constructional features. Another example which may be given is that of certain well-known Hungarian-made vehicles, of which many are to be found in service on Continental, Egyptian, and South American railways.

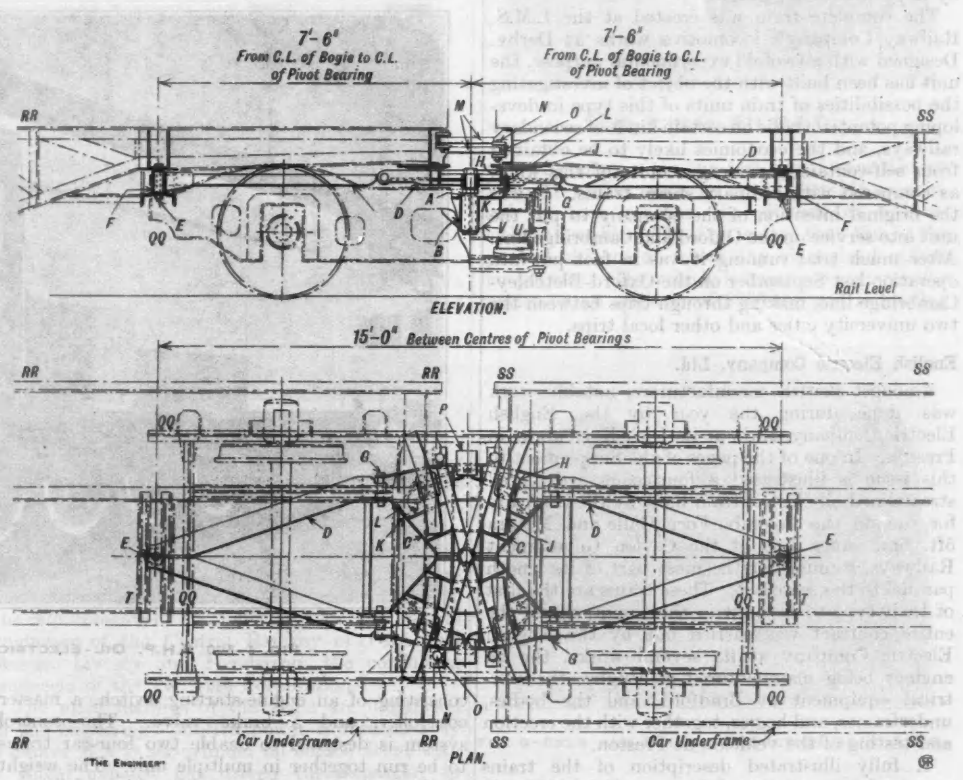
Other developments which may be regarded with interest are the experiments being conducted in Germany with a directly driven oil-engined locomotive, details of which were given to the Engineers' German Circle meeting held at the Institution of Mechanical Engineers on January 17th, 1938, and the progress in France and other countries of producer gas plant for rail vehicle propulsion.

BRITISH PRODUCTIONS

L.M.S.-Leyland Motors, Ltd.

Regarding railcars and trains made by British manufacturers during the year 1938 for service on this country's railway system, if Ireland be excluded, there is but one example. Nevertheless, this single effort represents a new type of vehicle for this country and both Leyland Motors, Ltd., and the L.M.S. Railway are to be congratulated on their joint product. This train, which consists of a three-car articulated rake, propelled through hydraulic torque converters, by six Leyland oil engines, developing an aggregate of 750 B.H.P., is illustrated in one of the engravings in the Supplement to this issue. In view of the very full description which appeared in these columns in our issues of April 1st and April 8th, 1938, at the time of its official demonstration, we describe below only the main features of the train.

Seating accommodation is arranged for twenty-four first-class and 138 third-class passengers, and the weight of the complete unit is 73 tons. With a power-to-weight ratio of more than 10 H.P. per ton, the train is able to compete with electric traction for services involving many stops. At the time of the trial run Mr. W. A. Stanier, chief mechanical engineer to the L.M.S. Railway and designer of the train, said that the reason for adopting special means of articulation for the bogies was to obtain extra accommodation in the central coach. Permitting the use of longer car bodies than has hitherto been possible, the articulating mechanism is interesting and novel. The three-car train is carried on four bogies, of which the central two form the articulated supports for the centre car and the inner ends of the first and third cars. The arrangement of articulation is clearly shown in the accompanying line engraving, Fig. 1. A horizontal link, 15ft. long, is pivoted at its centre at the bogie centre, and at its ends to the car underframes.



A Centre pin.
B Silentbloc bearing to centre pin.
C Articulating link (centre section).
D Articulating link (end section).
E Pivot pins to links.
F Silentbloc bearing to link pins.
G Pins to knuckle joints.
H Roller support to underframe.
J Race plate to roller support.
K Bogie bolster friction block.
L Friction plates to friction block.
M Centring rods.
N Pins to centring rods.
O Silentbloc bearings to centring rod.
P Lubrication to roller bearings, &c.
Q Q Articulated bogie.
R R Framing members to first car.
S S Framing members to second car.
T Supporting frame to pivot bearing.
U Swing beam to bogie.
V Bogie centre framing.

FIG. 1—PLAN AND ELEVATION OF L.M.S.-LEYLAND ARTICULATED BOGIE

The weight of the bodies and frames is, however, taken by rollers on the bogie bolster, the link being hinged to allow for slight vertical relative movement between the bodies. In this way the versed sine of the bodies on a curve is reduced, enabling the bogies to be separated to the full extent permitted by the existing switch-locking bars in the track. The company states that this is the first time such an articulating mechanism has been used in this country.

As mentioned above, six Leyland oil engines, two of which are mounted in each car, each drive a separate axle through Leyland torque converters. Each engine develops 125 B.H.P. at its governed speed of 2200 r.p.m. in six cylinders with bores and strokes of 4½in. and 5½in., respectively. Each torque converter is provided with free wheels, which operate on both direct and indirect drives. Final drive and reversing is effected through double reduction gear-boxes. Each engine and transmission unit is carried on a main underframe, situated under the floor between the bogies of each car. The control of all the engines, torque converters, reversing gears, and all other equipment is simultaneously effected from either end of the train by means of an electro-magnetic system developed by Leyland Motors, Ltd.

The complete train was erected at the L.M.S. Railway Company's locomotive works at Derby. Designed with a twofold experimental purpose, the unit has been built with the object of investigating the possibilities of train units of this type in developing potential traffic on certain kinds of secondary railways, and the economies likely to be obtained from self-contained passenger units of this kind, as compared with ordinary steam trains. It was the original intention of the company to put the unit into service on the Oxford and Cambridge line. After much trial running it was in fact put into operation last September on the Oxford-Bletchley-Cambridge line, making through trips between the two university cities and other local trips.

English Electric Company, Ltd.

Amongst British manufacturers, notable work was done during the year by the English Electric Company, Ltd., at its Dick-Kerr works in Preston. In one of the pages of the Supplement to this issue is illustrated a four-coach articulated streamlined oil-electric train built by the company for use on the Colombo Fort, Galle and Matara 5ft. 6in. gauge line of the Ceylon Government Railways, running for the most part of its length parallel to the sea coast. These trains are the first of their type to be built in this country, and the entire contract was carried out by the English Electric Company at its several works, the oil engines being manufactured at Rugby, the electrical equipment at Bradford, and the bodies, underframes, and bogies, together with the erection and testing of the vehicles, at Preston.

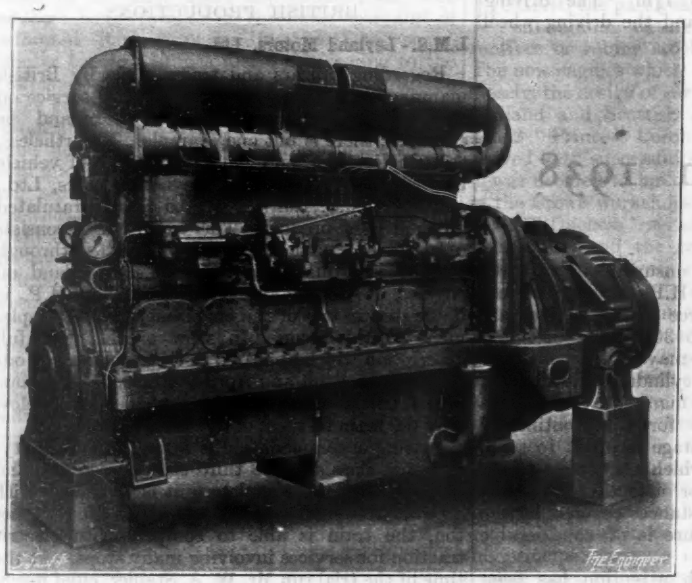
A fully illustrated description of the trains appeared in our issue of January 28th, 1938. It will be recalled that each train is formed by two power coaches, one at each end, with two trailer coaches interposed. Each of the power coaches, which are identical, is fitted with one of the firm's six-cylinder oil engines, developing 220 B.H.P. at 1500 r.p.m., but for this particular duty the engines are governed to 1350 r.p.m., at which the power output is 180/200 B.H.P. The main generator is directly coupled to the engine, as shown in Fig. 2, and the exciter is overhung from the main generator. A three-point suspension arrangement has been adopted for mounting the complete engine-generator unit in the coach. Each power unit supplies two traction motors, which are mounted on the bogie beneath the engine compartments. In Fig. 3 is shown the control switchgear. A full technical description of the power units formed the subject of an article in these pages in our issue of February 25th, 1938.

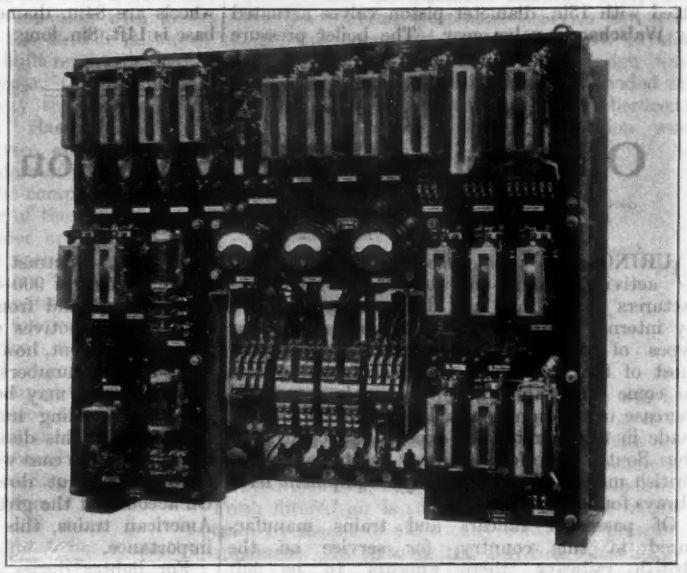
In the design much use has been made of welded steel. The bogies are of all-welded steel construction, and the coaches are fabricated, the steel body and underframe being welded to each other, forming an integral welded structure. Two electrically driven exhausters are provided on each four-car unit for operating clasp brakes by an automatic vacuum system. All the axles are fitted with roller bearings.

At each end of the four-car unit is arranged a driver's cab, with the controls conveniently mounted on a desk. These controls are simple, consisting of an engine-starting switch, a master controller, and a brake valve. The control system is designed to enable two four-car trains to be run together in multiple unit. The weight of the train in working order with a full complement of passengers and luggage is 116 tons, and the maximum speed attainable on the level is 55 m.p.h.

Another new production during the year by the English Electric Company is illustrated by the engraving herewith, Fig. 4, showing one of three 500 B.H.P. oil-electric passenger locomotives for the metre-gauge Eastern Railway of Brazil. These locomotives are the first oil-electric passenger locomotives to be constructed for a Brazilian railway, and a new train, painted blue to match the colour scheme of the locomotives, is being put into service to be hauled specially by the new engines. Capable of exerting a maximum tractive effort of 18,000 lb., the locomotives, of 2-8-2 wheel arrangement, weigh in working order 55 tons. One of the company's eight-cylinder oil engines is fitted, directly coupled to a main generator with an overhung exciter, and, as with the trains described above, the complete engine-generator unit is carried on three points. The generator supplies two axle-hung forced-ventilated traction motors mounted on two of the driving axles, which are coupled in pairs by side rods, each pair being driven by one traction motor. The cab is provided with two driving positions, one for each direction of running, and each driving position is fitted with a master controller, a brake valve, engine-starting switch, and so forth. The control system embodies the firm's patented direct torque-control apparatus, for a further description of which reference should be made to the articles mentioned above. This apparatus automatically adjusts the loading of the generator at varying locomotive loads and speeds.

The auxiliary equipment includes automatic air brakes which are supplied by two motor-driven compressors. The radiator is mounted at the front of the locomotive, and air is drawn through it and expelled through the top of the engine compartment by means of a fan. Below the radiator are fitted air filters, through which air





FIGS. 2 AND 3—180/200 B.H.P. OIL-ENGINE GENERATOR AND CONTROL SWITCHGEAR FOR OIL-ELECTRIC TRAIN—E.E.C.

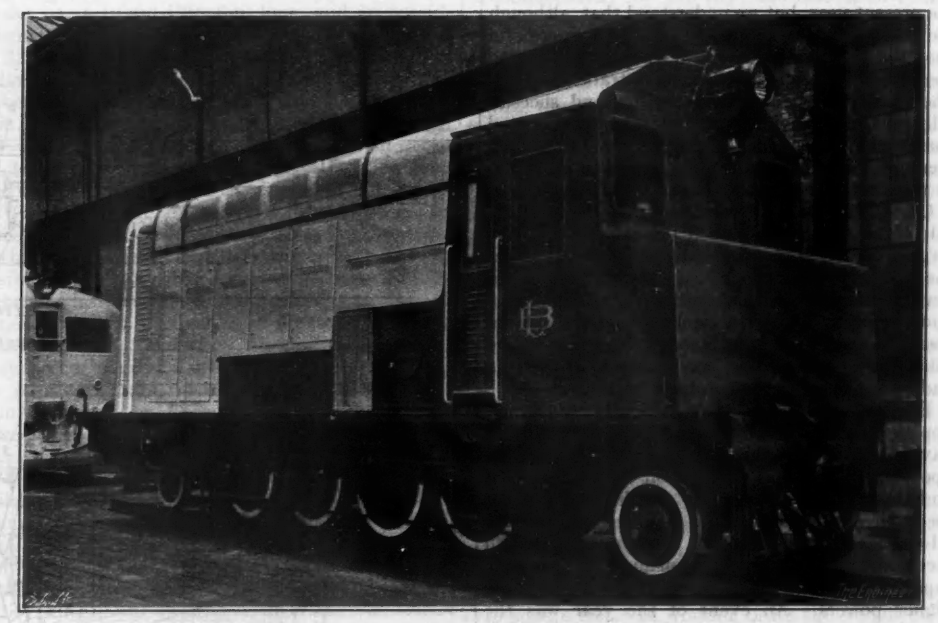


FIG. 4—500 B.H.P. OIL-ELECTRIC LOCOMOTIVE FOR BRAZIL—E.E.C.

is drawn by a blower delivering to the traction motors. Both the blower and the radiator fan are belt driven from the engine. Both engines and electrical equipment were manufactured by the English Electric Company at its Rugby and Bradford works respectively. The mechanical parts were supplied by Robert Stephenson and Hawthorns, Ltd. Assembly and testing of the

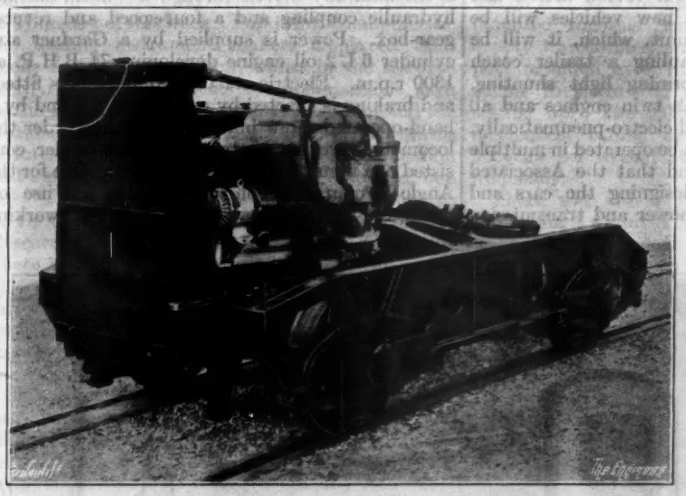


FIG. 5—150 B.H.P. CONVERSION BOGIE—WICKHAM

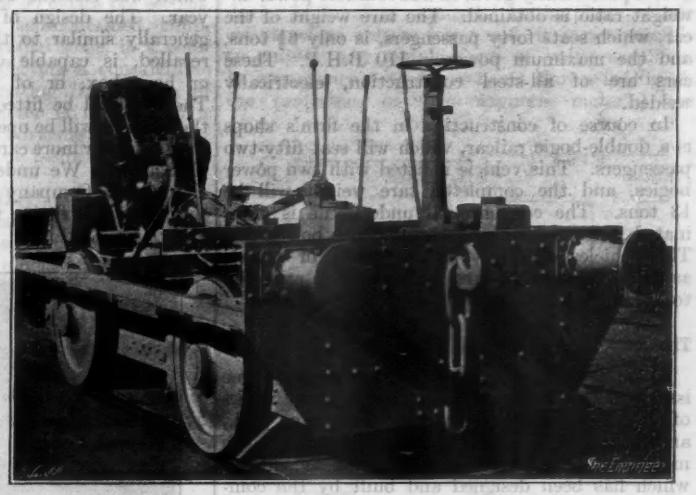


FIG. 6—CHASSIS OF OIL-ENGINED SHUNTING LOCOMOTIVE—A.E.C.

locomotives was carried out at the Preston works of the English Electric Company.

Before turning from the products of the English Electric Company, brief mention should be made of an important contract for oil-electric locomotive equipments awarded to the company in August of last year. This contract is for the construction of twenty 350 B.H.P., 0-6-0 oil-electric shunting locomotive equipments for the L.M.S. Railway Company, to be used for general shunting duties and for intensive hump-shunting purposes. Each locomotive will be fitted with one of the firm's oil engines developing 350 B.H.P. at 680 r.p.m., directly coupled to a D.C. generator. The drive will be through a single traction motor mounted in the superstructure, to a jackshaft coupled to the wheels. The locomotives will be provided with torque control and mechanical drives to all auxiliaries. The oil engines and all the electrical equipment will be manufactured by the company at its Rugby and Bradford works, respectively. Certain mechanical parts will be manufactured and the locomotives will be assembled in the L.M.S. works at Derby.

Robert Stephenson and Hawthorns, Ltd.

Apart from the oil-electric locomotives for the design of which Robert Stephenson and Hawthorns, Ltd., have been in collaboration with the English Electric Company, described above, the first-named firm is constructing at its Forth Banks Works, Newcastle, nine oil-engined geared locomotives for service in a Government filling factory. The prime mover is a reversible five-cylinder Crossley engine, driving through a Vulcan-Sinclair traction coupling and a two-speed rotary gear-box. An air-operated brake is used for obtaining the first speed, 4 m.p.h.; second speed, 8 m.p.h., is taken through a Cooper multi-plate clutch. The drive is then taken through a worm and wheel main reduction gear, the wheels, 3ft. 4in. in diameter, being driven by coupling-rods. Compressed air is supplied by three built-in compressors at a pressure of 350 lb. per square inch, and air for the brake is taken from storage bottles having a capacity of 10 cubic feet, through a Westinghouse reducing valve supplying air at 70 lb. per square inch. The electric lighting equipment is of special flameproof design, and the batteries and C.A.V.-Bosch dynamo are enclosed in flameproof cases. In order to make the exhaust flameproof an arrangement comprising a wet silencer, with a water supply tank, is fitted. We understand that these locomotives are similar to the locomotive built by the firm for Thomas Firth and John Brown, Ltd., which was fully described in THE ENGINEER of November 26th, 1937.

D. Wickham and Co., Ltd.

Two interesting railcar types are under construction at the works of D. Wickham and Co., Ltd., of Ware, Herts, and, in addition, there has been sent out from this works a conversion oil-engined power bogie, which was supplied by the company to the Peruvian Central Railway for converting an existing steam railcar. The conversion bogie, illustrated in the accompanying engraving, Fig. 5, was built to replace a steam railcar which was operating, not very successfully, on a main line

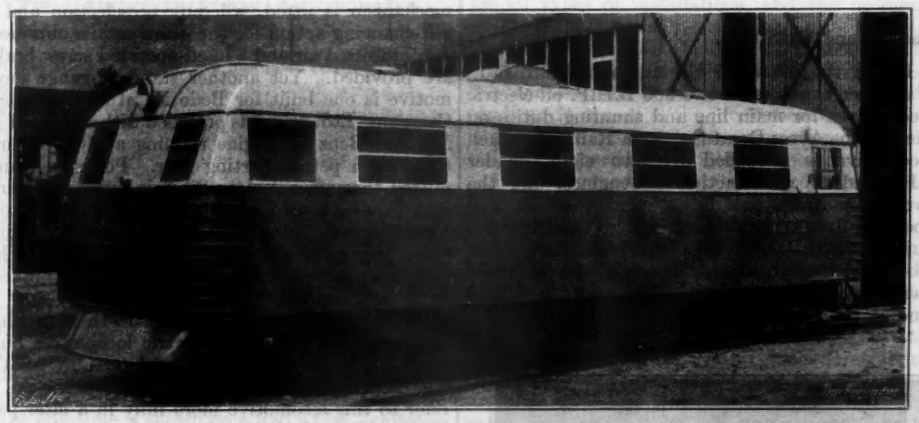


FIG. 7—110 B.H.P. RAILCAR FOR BUENOS AYRES GREAT SOUTHERN RAILWAY—WICKHAM

section from Callao to Oroya, which has 75 miles of rising gradients of up to 1 in 22, and reaches a height of 15,800ft. above sea level. It was therefore decided to rebuild the car, and D. Wickham and Co., Ltd., were entrusted with the development and construction of the power bogie to the requirements of Mr. Jefferson, chief mechanical engineer of the Central Railway of Peru, and Messrs. Livesey and Henderson, the consulting engineers of the Peruvian Corporation.

The main features of the bogie are illustrated in the engraving. Motive power is furnished by a Saurer B X D six-cylinder oil engine fitted with a Büchi exhaust gas driven turbo-charger, to enable a reasonable output to be obtained from the engine when working at high altitudes. For example, the unsupercharged normal output of this engine at 1500 r.p.m. is 150 B.H.P. at sea level, but the available power supercharged at 5000ft. and 15,000ft. is 155 B.H.P. and 120 B.H.P., respectively, at the same speed. The drive from the engine is taken through a Vulcan-Sinclair fluid coupling to a four-speed Cotal electro-magnetic epicyclic gear-box, thence to the final reduction and reverse gear-box, of David Brown manufacture, on one axle of the bogie. The bogie itself is of all-welded construction, and has several noteworthy points in its design, for a description of which we have no space in the present article. We hope, however, to make this power bogie and the methods used in the manufacture of the railcars built by this firm, briefly mentioned below, the subject of a separate article in a future issue.

With regard to the power bogie, the converted railcar has now been in service for a short period, and favourable reports have been received as to

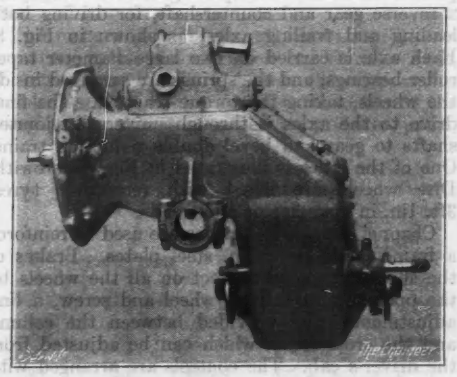


FIG. 8—GEAR BOX—A.E.C.

its performance. On the test run it exceeded its designed performance by a comfortable margin, and, in fact, reached the altitude of 4758 m. without trouble. The firm states that this is the greatest altitude at which any oil-engined railcar has yet run. The vehicle is being put into regular service at an altitude of 3700 m., and is hauling

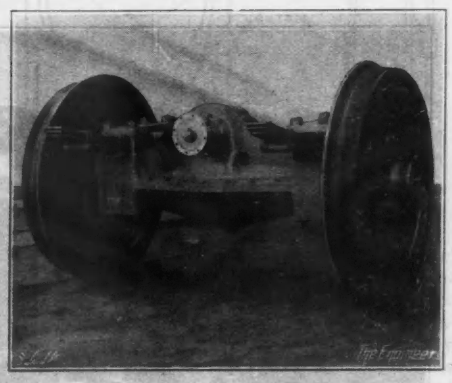


FIG. 9—AXLE AND DOUBLE REDUCTION GEAR—A.E.C.

a trailer—a duty which was not specified when the design was got out.

In Fig. 7 is shown one of six petrol-engined railcars manufactured by D. Wickham and Co., Ltd., for the Buenos Ayres Great Southern Railway, for a fast service in the outlying districts served by the railway company in competition

with road transport. Each car is propelled by a Lincoln twelve-cylinder petrol engine, driving one of the two axles through a plate clutch, a four-speed gear-box and double bevel reverse gears in the driven axle. Driving controls are fitted at each end of the car. Fully loaded the maximum speed is 50 m.p.h.—a figure which, although not high, is sufficient for the purpose in view. It is claimed, however, that the acceleration is particularly good, as a favourable power-to-weight ratio is obtained. The tare weight of the car, which seats forty passengers, is only 6½ tons, and the maximum power is 110 B.H.P. These cars are of all-steel construction, electrically welded.

In course of construction in the firm's shops is a double-bogie railcar, which will seat fifty-two passengers. This vehicle is fitted with two power bogies, and the completed tare weight will be 13 tons. The conventional underframe is eliminated, the body being constructed as a box girder. The vehicles of this type are made, of course, as self-propelled railcars, and are not expected to be coupled.

The Associated Equipment Co., Ltd.

In an article which appeared in the last three issues of THE ENGINEER, we described the works of the Associated Equipment Company, Ltd., and in the issue of December 16th, 1938, we mentioned and illustrated a shunting locomotive which has been designed and built by the company, and which is in use at its works. This locomotive, the chassis of which is illustrated in the accompanying engraving, Fig. 6, falls in the 0–4–0 class of shunters. It is fitted with a four-cylinder oil engine, of the company's manufacture, which has an output of 78 B.H.P. at 1700 r.p.m.; alternatively, the locomotive can be supplied with a six-cylinder engine, in which case the tractive effort is increased by 50 per cent. All parts have been designed for the higher output. The drive is taken through a standard plate clutch to a four-speed gear-box embodying a reverse gear and countershaft, for driving both leading and trailing axles, as shown in Fig. 8. Each axle is carried on two large-diameter taper roller bearings, and the springs are arranged inside the wheels, taking the torque reaction. The final drive to the axles is through universally jointed shafts to gear and bevel double reduction trains. One of the axles is illustrated in Fig. 9 herewith. Disc wheels are fitted with renewable tyres, 3ft. 1in. in diameter on the treads.

Channel and angle sections are used to reinforce a frame made from ¾in. steel plates. Brakes of the shoe pattern take effect on all the wheels by the operation of a hand wheel and screw, a link adjustment being provided between the column and the cross shaft, which can be adjusted from the driver's cab. The controls are arranged with central change-speed and reverse levers, a hand clutch, a sanding lever, and accelerator pedals in duplicate for operation from either side. The total weight of the locomotive in working order is 13 tons 5 cwt. 2 qrs. It has a wheel base of 7ft. 6in. The overall gear ratios for the four speeds are 15·7, 24·95, 42·2, and 68·7 to 1, with corresponding maximum speeds and tractive efforts of 11·9, 7·5, 4·4, and 2·7 m.p.h. and 2125 lb., 3220 lb., 5440 lb., and 8850 lb., respectively. An alternative axle ratio of 6·2 to 1 is available, giving correspondingly higher speeds and lower tractive efforts. The standard axle ratio is 7·85 to 1.

We noted in our issue of March 4th, 1938, that the G.W.R. had ordered twenty more railcars, similar to those already in service, built by the Associated Equipment Company, Ltd. This order follows upon the delivery of the last of eighteen vehicles, which was referred to in our review article last year. The design of the new vehicles will be generally similar to that unit, which, it will be recalled, is capable of hauling a trailer coach or horse-box, or of performing light shunting. The cars will be fitted with twin engines and all the controls will be operated electro-pneumatically, so that two or more cars can be operated in multiple if required. We understand that the Associated Equipment Company is designing the cars and supplying and fitting the power and transmission units, but that the construction of the bogies, underframes, bodies, and the fitting of automatic train control apparatus is being carried out in the Great Western Railway's works at Swindon. It is expected that the cars will be delivered during the early part of this year.

Harland and Wolff, Ltd.

During the year 1938 Harland and Wolff, Ltd., of Belfast, constructed two 900 B.H.P. oil-electric locomotives for main line and shunting duties on the Buenos Ayres Great Southern Railway. Each locomotive is propelled by two eight-cylinder "Harlandic" rail traction oil engines, and the two locomotives can be coupled together and operated from one cab. In addition, the firm has built a 225 B.H.P. oil-engined shunting locomotive with mechanical transmission for use in its own works. This design is fitted with a "Harlandic" six-cylinder engine and an S.L.M. gear-box.

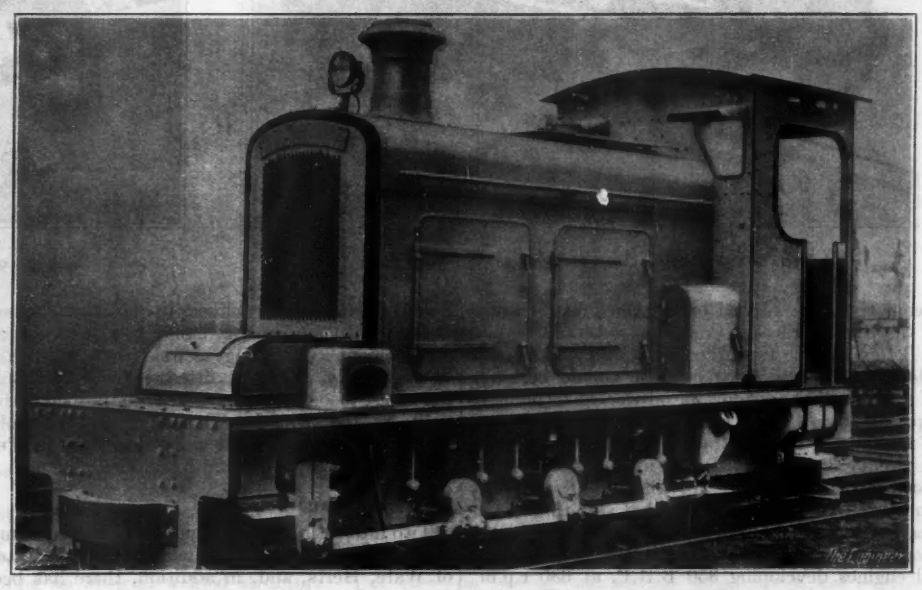


FIG. 11—74 B.H.P. SHUNTING LOCOMOTIVE—HUDSWELL

An illustration of the locomotive is reproduced in the accompanying engraving, Fig. 10.

Hudswell, Clarke and Co., Ltd.

In Fig. 11 there is shown one of the shunting locomotives built by Hudswell, Clarke and Co., Ltd., of Leeds. It has been built for the Colonial Sugar Refining Company, Ltd., for service on a 2ft. gauge line. Of the 0–6–0 type, the locomotive is mechanically driven through a Vulcan-Sinclair hydraulic coupling and a four-speed and reverse gear-box. Power is supplied by a Gardner six-cylinder 6 L 2 oil engine developing 74 B.H.P. at 1300 r.p.m. Electric starting equipment is fitted, and braking is effected by compressed air and by a hand-operated screw brake. In working order the locomotive weighs 12 tons. Another order consisted of a flame and spark-proof locomotive for the Anglo-Iranian Oil Company. It is for use on standard 4ft. 8½in. gauge lines, and in working order weighs 28 tons. A Gardner 8 L 3 eight-cylinder engine, fitted with an air motor starter, furnishes the motive power, which is transmitted through a constant-mesh gear-box incorporating baulking rings and an auxiliary clutch, providing three speeds in either direction. A "Tele-change" mechanism is fitted, whereby preselection and a self-changing action for the gears can be obtained. A compressed air and a hand-operated screw brake are provided. Yet another standard-gauge locomotive is one built for Bede Metal and Chemical Company, Ltd., which is provided with a 125 B.H.P. McLaren-Benz oil engine running at 1000 r.p.m., fitted with petrol starting gear. Power is transmitted through a Vulcan-Sinclair hydraulic coupling, furnished with an idling drag eliminator, to a constant-mesh gear-box incorporating baulking rings, giving three speeds in either direction. This locomotive also is fitted with air and hand brakes; in working order it weighs 25 tons.

In our Supplement to this issue there is illustrated a 4400 B.H.P. oil-electric locomotive built by Sulzer Brothers, Ltd., of Winterthur, for the Roumanian State Railways. It is proposed to refer to this locomotive more fully in a later part of this article, dealing with manufacture abroad.

(To be continued)

FIG. 10—225 B.H.P. OIL-MECHANICAL LOCOMOTIVE—HARLAND

FOSSE WAY IMPROVEMENTS.—The Minister of Transport has made a grant from the Road Fund towards the cost of modernising a further length of the Leicester to Lincoln road, the important cross-country route, which for over 50 miles follows the line of the historic highway known as Fosse Way. Three miles of this road on the south side of the Leicestershire and Nottinghamshire border were recently reconstructed with dual 20ft. carriageways, and it is now proposed to continue the improvement for a length of 5 miles on the north side of the county border from Sixhills to the junction with the Nottingham to Melton Mowbray road at Widmerpool. The cost is estimated at £114,000 and the work is expected to take two years. A feature of the scheme is the preservation of existing hedges and trees, the destruction of which will be avoided by retaining as much of the existing carriageway as possible and by building the second carriageway behind the hedges. The central space between the two carriageways will vary from 16ft. to 50ft. The minimum overall width of the road will be 106ft., as against an existing width of between 60ft. and 80ft. The railway bridge over the road near Widmerpool will have to be lengthened and widened to carry the second carriageway, and this work will be the subject of a separate grant.

The Physical Society's Exhibition

No. I

THE twenty-ninth annual exhibition of scientific instruments and apparatus was held under the auspices of the Physical Society at the Imperial College of Science and Technology from Tuesday to Thursday of this week. Following usual practice, the leading instrument makers displayed their goods in the trade section, whilst in the research section various individuals and organisations, such as the Post Office Engineering Department and the National Physical Laboratory, showed apparatus of interest to those engaged in scientific education and research. Two discourses were delivered, one on "The Cyclotron and its Applications," by Dr. J. D. Cockcroft; and the other on "Geophysical Research in Polar Regions," by Mr. C. S. Wright. There was the usual exhibition of work submitted by learners and apprentices for the draughtsmanship and craftsmanship competition. For the most part the exhibits consisted of electrical instruments and apparatus, although the show still has an optical side.

The stand of the Cambridge Instrument Company was devoted to a display of galvanometers of all kinds, ranging from the simplest instrument for routine work in schools to the most refined and highly sensitive instruments for the research worker. Many improvements in the design of galvanometers have been made possible by the developments in materials of construction, notably high-retentivity magnet steels, bakelite mouldings, &c. One of the instruments shown for the first time was a compact form of Einthoven string galvanometer (Fig. 1), incorporating a permanent magnet made of a special alloy. The air gap has been reduced so that the field strength is greatly increased, with a corresponding increase in the sensitivity. The fibre case, which is readily interchangeable, is composed of a material having a negligible temperature coefficient, thus retaining stability of calibration.

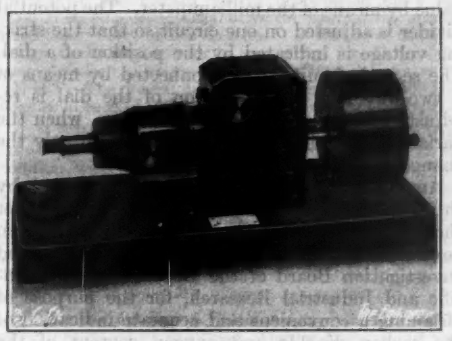


FIG. 1—EINTHOVEN STRING GALVANOMETER—CAMBRIDGE

Among the recording galvanometers was the recently designed Cambridge model "A" thread recorder. This robust, metal-cased instrument can be fitted with two, three, or four threads of different colours. A clock-driven rocking mechanism brings the thread under the galvanometer pointer and connects the corresponding circuits to the instrument. The pointer is automatically depressed at frequent intervals to form the records. The particular circuit connected up at any time is shown on a dial which exhibits a figure corresponding to the circuit. The figure is coloured in accordance with the colour of the particular record. The twenty-five-hour charts are 5in. wide. By fitting two galvanometer movements in one case six or eight independent records are obtained. The recorder can be supplied with suspended coils of various resistances, up to 5000 ohms, with a maximum sensitivity of 5 mA for full-scale deflection. Suitable for wall mounting or for flush mounting on a panel, the instrument is particularly well adapted for industrial use as a recording pyrometer, &c.

Another continuous chart recorder exhibited gives up to six continuous records in different colours on a chart 5in. wide at a speed of ½in. per hour. As a considerable length of the chart is visible, the record for the past eighteen hours can be examined at any time without opening the instrument. The particular circuit connected up at any moment is indicated in a similar manner to that adopted in the model "A" thread recorder. This recorder is also suitable for wall or flush mounting, and has many industrial applications.

One of the A.C. galvanometers was a new spot vibration instrument (Fig. 2), comprising the well-known Cambridge pot galvanometer arranged for use on A.C. at a frequency of 50 cycles per second, mounted together with a self-contained lamp, supply transformer, and a radial scale, in a compact moulded case, thus effecting a considerable saving in space and eliminating the trouble of setting up. The galvanometer is fitted with a mechanical tuning device covering a range of 5 cycles per second above or below the nominal frequency.

There was also a new thermal milliammeter, comprising a unipivot galvanometer with a thermal scale. The instrument is used in conjunction with vacuo-junctions which are plugged into a socket in the top board of the instrument. A compartment is provided in which spare vacuo-junctions are carried.

A "telebrightness" meter, exhibited by the British Thomson-Houston Company, Ltd., is designed on the lines of a theodolite and is used for accurate measurement of surface brightness in street lighting installations. Brightness measurements are obtained by fading the mirrored image of a test surface into the section of the surface viewed through the telescope. Colour filters cater for all types of installations, and the necessary brightness range is achieved by means of standard neutral density filters and a calibrated iris diaphragm. The instrument is capable of measuring brightnesses from 0·001 to 100 equivalent foot-candles. It is used in the production of standardised photographs and in conjunction with the B.T.H. post-recording brightness meter.

FIG. 2—SPOT GALVANOMETER—CAMBRIDGE

Apparatus was shown for the study of lamp mounting under vibration conditions. The general use of modern electric discharge lamps has introduced a difficult problem with regard to lamp construction. The light source is contained in an arc tube of glass or quartz, which is often of considerable weight and has to be mounted inside a glass protective jacket. The problem is to support this weight with sufficient rigidity without straining any part of the lamp. Rigid constructions tend to transmit shocks directly to glass or quartz parts, but if any flexibility is allowed care must be taken to see that there is a minimum movement at the more delicate points, such as at welds. The exhibit showed how the use of a stroboscopic light tube can be of great assistance for solving this electric discharge lamp construction problem. Experimental lamp mounts were shown fixed to a spring-mounted base alongside an excentrically loaded electric motor. Variation of the motor speed causes the lamp mount to be vibrated, and considerable movement was produced at the resonant frequencies. The movement of the mount is apparently slowed down or stopped by suitable adjustment of the stroboscopic tube flash frequency, and in this way the relative movement of the various parts of the lamp can be noted with ease.

Another exhibit was designed to show the acceleration of phosphorescence by increase of temperature. A phosphorescent screen is excited by intermittent ultra-violet light. During the phosphorescence period parts of the screen, which take the form of letters, are heated, and the stored light in these parts is rapidly radiated. In consequence, the letters show brightly against the uniform background. But when the heating is stopped, the temperature becomes again uniform and the letters appear dark relative to the background, since much of the stored light has been spent.

The arrangement shown in Fig. 3 was used to illustrate the use of a selenium photo-voltaic cell for controlling the flow of current in a circuit. The electrical output from the cell is insufficient to operate a robust relay and some form of amplifying device is therefore required. As the photo-voltaic cell develops only a low e.m.f., it is not possible to employ any simple form of valve amplifier. In accordance with the scheme shown in Fig. 3, the properties of ferro-magnetic material are

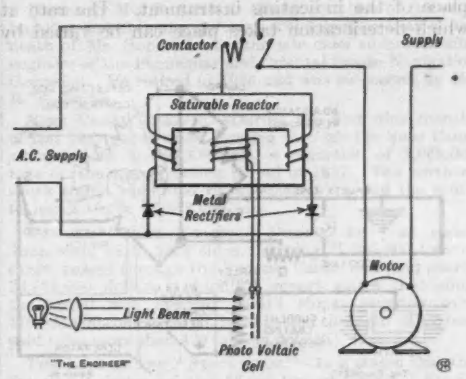


FIG. 3—AMPLIFYING CIRCUIT—B.T.H.

utilised to obtain the necessary amplification. When the photo-voltaic cell is illuminated, the current it generates is passed through an auxiliary winding around one leg of the core of a saturable reactor. Through main windings of this reactor the contactor coil is fed from the mains and the change in impedance of the main coils, caused by the passage of current in the auxiliary coil, controls the operation of the contactor which is used to start and stop an electric motor.

The megger paint tester, shown in Fig. 4, was one of the exhibits of Evershed and Vignoles, Ltd., of Acton Lane Works, Chiswick. This apparatus enables a rapid determination to be made of the comparative values of different kinds of paint,

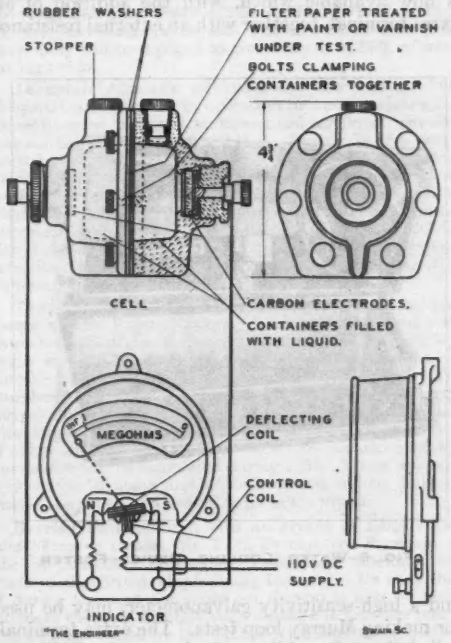


FIG. 4—PAINT TESTING APPARATUS—EVERSHED AND VIGNOLES

varnish, and other coating materials, such as wax, enamel, linseed oil, &c. In the past these comparative values have been obtained by many months' exposure to the atmosphere or by immersing the materials in suitable solutions for lengthy periods. In the light of recent research, paints and other coating compositions may be considered as membranes which, although initially impermeable, become permeable as the material deteriorates, and by measuring the rate of decay of the osmotic or electrosmotic resistivity of the paint membrane, the comparative life of different coatings can be compared in the course of a few hours.

The apparatus consists of a cell or number of cells connected to an indicating or graphic recording ohmmeter. The cell is composed of moulded

insulating material and is made in two parts, each containing a carbon electrode. The test piece, consisting of a layer of filter paper coated on both faces, or impregnated, with the paint, is placed between the two parts of the cell, which are then bolted together. A water-tight joint is made by two rubber rings. The compartments on each side of the test piece are then filled with a conducting solution and electrical tension is applied between the two carbon electrodes. The resistance is measured on an ohmmeter. The ohmmeter equipment exhibited was provided with socket connections for ten cells and a jackboard so that readings from each cell could be taken at intervals. If continuous observation is required on any particular cell a recording ohmmeter can be used in place of the indicating instrument. The rate at which deterioration takes place can be varied by

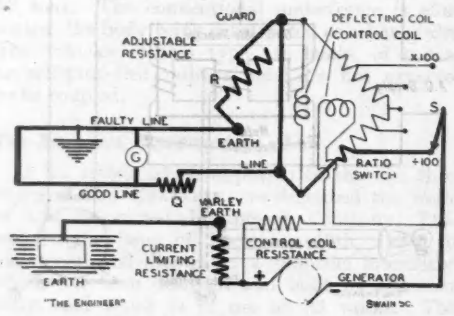


FIG. 5—CIRCUIT OF BRIDGE MEG TESTING SET —EVERSHED AND VIGNOLES

the nature and strength of the solution on each side of the paint membrane. The makers have been using this apparatus for some time in connection with the testing of insulating varnishes, and have obtained valuable information regarding the most efficient temperatures and times of stoving. Information has also been obtained on the relative values of insulating cloth. Some cloths break down after twenty minutes, whereas under similar conditions others will last for twenty-two days.

Another exhibit on this firm's stand was a Bridge Meg testing set, adopted for Murray loop tests. The set has been used for many years for making Varley loop tests, and a special instrument is now available which, with the addition of an extra terminal, together with an external resistance

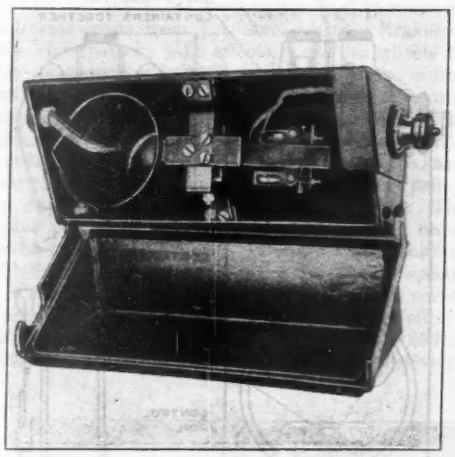


FIG. 6—WATER COOLING DEVICE—FOSTER

and a high-sensitivity galvanometer, may be used for making Murray loop tests. The extra terminal, called the "Guard" terminal, actually fulfils two purposes. When the change-over switch in the instrument is set for making insulation tests, this terminal is connected as a guard terminal, whereas for Varley and Murray tests the change-over switch connects this terminal as shown in Fig. 5. To make Murray loop tests the "Guard" and "Line" terminals are joined together and the ratio switch S set to an extreme position ($\div 100$ or $\times 100$). The ohmeter is not used in this test and is replaced by the high-sensitivity galvanometer G. The ratio switch S also is out of use, but the adjustable resistances R and Q provide the ratio arms. In the diagram thick lines are used to denote the actual operating circuit. If a slide wire potentiometer is used instead of the resistances R and Q, the "Varley Earth" and "Line" terminals only are used, the latter being connected to the sliding contact of the potentiometer.

The photo-electric high-speed recording pyrometer exhibited by the Foster Instrument Company, of Letchworth, last year, has been considerably improved and its usefulness greatly extended. A photo-electric cell is exposed to the radiation emitted by the hot body and the resultant electrical effect is converted and amplified to operate a direct-writing high-speed recorder. The cell, which is highly sensitive to the heat rays emitted, is mounted in a patented housing which limits its cone of "vision" to the hot body surface and provides for the water cooling necessary in hot situations. With all its accessory apparatus the amplifying unit is mounted on a hinged and sprung sub-frame and is enclosed in a hermetically sealed case, which is also water cooled.

Having obtained a response to temperature change at a speed hitherto unattained, the way was opened to making records which would not only show the mean temperature of a billet or bloom passing through rolls, but would also show and analyse the temperature distribution along the

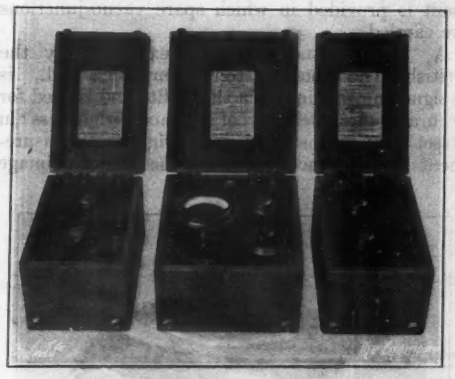


FIG. 7—PEAK COMPARATOR—ELLIOTT

billet almost foot by foot even when passing at high speed. The only other requirement was a recorder which could respond instantaneously and without overshoot to such rapid changes in the recording current. No available instrument conformed with these requirements, but by re-designing an existing instrument the desired results were secured. The recorder exhibited has an open temperature scale, on which variations as small as 5 deg. can be seen at a glance, with a completely unobscured record.

In conjunction with this apparatus was shown a water cooling safety device. In many pieces of apparatus in industrial use protection from overheating has to be provided by enclosure in a water-

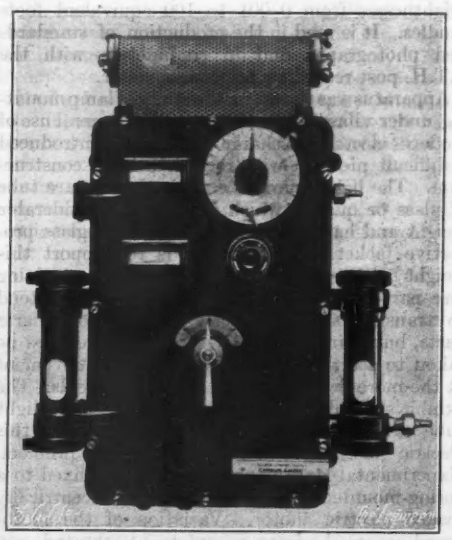


FIG. 8—COMBINED CO_2 AND OXYGEN METER —ELLIOTT

cooled housing. The photo-electric high-speed apparatus described is an example. It is common experience that the flow of cooling water may be interrupted or diminished without the knowledge of the person in charge of the apparatus, often with resulting damage, and to meet such cases safety apparatus (Fig. 6) has been devised and patented. After passing through all the cases which have to be cooled the water is led to a pipe from which it flows into a beaker. This beaker has a small orifice in the bottom forming a leak of such magnitude that the minimum safe flow of water will just keep the beaker full; any excess flowing over the lip into the containing tank and thence to waste. The beaker is mounted at one end of a pivoted beam. At the other end are sealed tilting switches, arranged so that one is normally closed, to supply current to the cooled apparatus, and the other, normally open, in an alarm circuit. Any momentary interruption of the flow of cooling water is not sufficient to empty the beaker, and the pivoted beam remains in the normal position. But continued interruption or diminution of the flow results in the gradual emptying of the beaker; thus the beam tilts, cuts off the current from the apparatus, and operates the alarm. On resumption of the water flow the beam is automatically restored to the normal position. Similar arrangements are applied to air cooling.

The Shotter-Elliott peak comparator shown in Fig. 7 was one of the exhibits of Elliott Brothers (London), Ltd., of Century Works, Lewisham, S.E.13. The apparatus enables the percentage change in peak factor of the voltage wave form of the mains supply to be measured directly. It therefore enables the requirement under the Meters Act, that A.C. circuit control apparatus shall not affect the peak factor by more than 3 per cent., to be checked. The apparatus comprises three units. The first deals with voltages from 200 to 250 volts, the second enables lower output voltages down to 8 volts to be tested, and the third unit enables the peak factor of the output current wave to be compared with the peak factor of the input applied voltage. The apparatus consists of a neon detector with a small A.C. milliammeter, together with adjustable rheostats and transformers. The method consists of comparing the striking voltages of a neon lamp on each circuit by passing a known r.m.s. current from each circuit in turn through a non-inductive potential divider. The r.m.s. current is set to a definite value by means of the milliammeter. The potential divider is adjusted on one circuit so that the striking voltage is indicated by the position of a dial. The second circuit is then connected by means of a two-way key. The position of the dial is readjusted to the second striking voltage, when the variation in position of the dial gives directly the change in the peak factor in percentage.

Among many other instruments exhibited by this firm was the combined CO_2 and oxygen meter shown in Fig. 8. The instrument has been developed on the lines laid down by the Food Investigation Board of the Department of Scientific and Industrial Research, for the purpose of obtaining a convenient and accurate indication of the carbon dioxide and oxygen content of the atmosphere in cold stores. It depends in principle upon the fact that the thermal conductivity of carbon dioxide differs appreciably from that of the other gases normally present, and employs a Siemens measuring unit, having two conductivity chambers, each containing two hot platinum wires, the four wires being connected in the form of a Wheatstone's bridge. If the carbon dioxide of the gas in one chamber differs from that in the other a disturbance of the electrical balance of the bridge results, which is a measure of this difference. The power required to operate the apparatus is about 250 watts A.C. or 300 watts D.C.

(To be continued)

THE HISTORY OF ELECTRIC LIGHTING.—The Ediswan collection of historic lamps, recently inaugurated by Dr. A. P. M. Fleming, President of the Institute of Electrical Engineers, is now permanently open as a free public museum on the premises of the Edison Swan Electric Company, Ltd., 155, Charing Cross Road, London, W.C.2. It is said to be the most complete collection of its kind in England, and, so far as it is known, in the world. The exhibits are the property of the Edison Swan Electric Company, Ltd., and were accumulated during the period between 1878, when Sir Joseph Swan made the first practical incandescent electric lamp, and the present day. In it may be seen the successive stages in the history of domestic electric lighting and the development of incandescent electric lamps for all practical lighting purposes. Some of the lamps have been in use, others are "new" lamps retained purely as specimens, but, nevertheless, practical lamps made for sale and use. This collection is intended to be permanently open to free public view, and with the passage of time it will be developed and augmented. It is hoped that it will become a recognised source of reference for the student and interest, entertainment, and instruction to the public. Items of outstanding interest in a collection of over 250 interesting exhibits are Sir Joseph Swan's first lamp, 1878, the first Swan commercial lamp, the first drawn wire lamp, the largest incandescent lamp ever made, the first lamp holders and switches, and many unusual novelty lamps. The museum is open daily from 9 a.m. to 5.30 p.m. on week-days and from 9 a.m. to 12 noon on Saturdays.

Rail and Road

NEW FACTORIES.—There were fifty-four new factories established on the Great Western Railway Company's system during 1938.

ROAD WORK IN AMERICA.—It is reported by the United States Bureau of Public Roads that during the last financial year more than 15,000 miles of roads were improved, 711 level crossings eliminated, 144 level crossings reconstructed, and another 744 protected by signs and signals.

NEW ELECTRIC SERVICES ON THE SOUTHERN RAILWAY.—On Sunday, January 1st, the Southern Railway Company introduced new electric services on the lines between Virginia Water and Reading *viâ* Ascot, Ascot and Ash Vale, Frimley and Pirbright Junction, and Guildford and Aldershot. This additional 43 route miles brings the electrified mileage of the company up to 655.

TRANSPORT IN BELFAST.—Following the operation of an experimental trolleybus service in Falls Road, the Belfast Corporation has decided to abandon the tramway system and gradually introduce trolleybuses. The Corporation has also decided to reject the recommendation that its tramway and bus services should be merged in an amalgamation of road and rail transport in Northern Ireland.

NEW L.M.S. TURNTABLES.—New vacuum-operated turntables are to be installed by the London, Midland and Scottish Railway Company at the following ten places on its system:—Plodder Lane (Bolton), Widnes, Keswick, Wellingborough, Sheffield (Grimesthorpe), Peterborough, Toton (Derbyshire), Evesham, Leicester, and Liverpool (Exchange). Eight of the new turntables will be of larger diameter than those which they replace, in order to accommodate bigger locomotives.

AUSTRALIAN RAILWAYS.—The report on Commonwealth Railways Operations for the year ending June 30th last, which covers the Trans-Australian, the Central Australia, the North Australia, and the Australian Capital Territory Railways, has recently been issued. It shows that the 2201 miles of line earned just under £443,000 during the year, working expenses being £511,500. The train miles totalled 758,259, the earnings per train mile being 11s. 8¼d. and the working expenses 13s. 6d.

NEW AMERICAN OIL-ELECTRIC LOCOMOTIVE.—The Union Pacific Railroad in the United States has placed an order with the Electro Motive Corporation for a new 4000 H.P. oil-electric locomotive for hauling the streamlined train "City of Los Angeles." It will be of the same design as the engines now in use, except for the fact that each of its four oil engines will develop 1000 H.P. instead of 900 H.P. The present locomotives each have two 900 H.P. engines in each of three units, making a total of 5400 H.P.

L.N.E.R. COLLISION REPORT.—The report has been issued on the Ministry of Transport inquiry into the collision which took place on July 12th last at York Station. The coaches of the 7.40 a.m. excursion train from Newcastle to Scarborough, which reversed direction at York, were standing with brakes applied when the engine which was to take the train forward struck the leading coach as it backed on with the tender leading. This accident was found to have been caused by a brake failure brought about by incorrect adjustment.

ACTIVITIES OF THE G.W.R.—Among the new rolling stock introduced by the Great Western Railway last year were 122 locomotives, including ten "Castle" class engines; 274 passenger vehicles and 2770 freight wagons. The company's engines ran 98,616,539 miles, and the average mileage between general repairs rose by 8000 to 159,000 miles. The eighteen railcars ran 976,000 miles—97,000 more than in 1937. On the road side the company is experimenting with a tractor fitted with a producer-gas apparatus using anthracite, and with a petrol-driven general delivery vehicle with a twin-cylinder, air-cooled engine beneath the body.

LONDON PASSENGER TRANSPORT BOARD.—During the past year the London Passenger Transport Board extended the trolleybus system over 66 route miles in North London, and during the coming year intends to extend the mileage by a further 33. It placed 100 new buses and 262 new coaches in service, as well as 370 new railway cars. During 1939 the new ticket hall at King's Cross Station will be opened; the Northern Line extended to East Finchley; trains on the Bakerloo Line will run to Stanmore, and the reconstructed Sloane Square Station will be completed. The reconstructed St. Paul's Station was opened on Sunday, January 1st.

SCOTTISH ROAD IMPROVEMENT.—The Minister of Transport has asked the Perth and Kinross County Council to put in hand immediately a scheme for the widening and modernisation of the Perth, Aberdeen, and Inverness trunk road between Longforgan and Invergowrie, for a length of about 1¾ miles. The existing road has a single carriageway, 21ft. wide, and there are also a few lengths of narrow footpath. At a cost of about £50,000, it is proposed to widen the road to 100ft., and provide dual carriageways, cycle tracks and footpaths. The carriageways will be 22ft. wide and the cycle tracks 6ft. The eastern end of the scheme lies in the county of Angus, but it has been agreed that the whole scheme shall be carried out by the Perth and Kinross County Council.

RAILWAY WORK IN NORWAY.—According to a recent report on the economic and commercial conditions in Norway, work is rapidly going forward on the construction of new sections on a number of the country's main lines. On the Sorland Railway the new 109-kilom. section, Kristiansand and Moi, is expected to be completed by 1945, and the new 51-kilom. section, Moi and Egersund, is progressing. On the Nordland Railway the new section, Grong and Mosjoen, 186·4 kilom. long, is expected to be finished in 1941, and work is in progress on the new 96-kilom. line from Mosjoen to Mo, and 240-kilom. line from Mo to Bodo. On the Flaam Railway the new branch line between Myrdal and Fretheim is expected to be completed in 1941. The reconstructed Vestfold Railway and Roros Railway will probably be opened to broad-gauge traffic in 1941 or 1942.

Miscellanea

THE COAL INDUSTRY.—A little book, entitled "100 Questions and Answers About Coal," has been published by Philip Gee. In it an attempt has been made to deal with the more important questions on the coal-mining industry which are commonly encountered.

ELECTRICITY SUPPLIES DURING THE COLD SPELL.—As a result of the recent cold spell, the demand for electricity throughout the country rose by more than 15 per cent. The load on the stations associated with the grid scheme increased to 6,714,000 kW on December 20th. In London and the South-Eastern Area the load on December 21st rose to 2,285,000 kW.

TESTING SEAMS IN TANKS AND PIPES.—A note in *Engineering News-Record* describes a seam-testing service for discovering leaks in tanks and pipe lines which has been inaugurated by an American company. The service makes use of a device consisting of an air-tight, rectangular box equipped with a vacuum gauge. The top of the box is covered with glass, and soft rubber strips are mounted around the base. When tests are to be made, a section of the seam is covered with a thick solution of soap suds. The device is placed over the covered area and a vacuum created by means of a suction pump. The suction compresses the soft rubber base of the device, sealing out the air. Imperfections in the seam will permit inflow of air, causing large clusters of soap bubbles to appear at that particular point, revealing the leak.

TIN AND TIN-PLATE PRODUCTION.—The December issue of the *Statistical Bulletin*, published by the Hague Office of the International Tin Research and Development Council, states that world tin production in the first ten months of 1938 amounted to 127,900 tons. The decrease is entirely accounted for by the signatory countries, which produced 104,700 tons in this period, whereas outside production at 22,500 tons showed a slight increase. World production in October amounted to 13,600 tons. World apparent tin consumption in the first ten months of 1938 amounted to 129,400 tons. The three chief tin-consuming countries, viz., the United States of America, the United Kingdom, and the U.S.S.R., show decreases from 25 to 40 per cent. Consumption in Germany, Italy, Poland, Sweden, Switzerland, and Japan increased by from 15 to 60 per cent. World tin-plate production in the first ten months of the year amounted to 2,399,000 tons, being a decrease of 35 per cent., as compared with the corresponding period of 1937.

CLAY.—A paper entitled "The Mysteries of Clay Structures" was recently given by Dr. Herbert Chatley to the Junior Institution of Engineers. Its main subject was the work of Terzaghi, which has formed the foundation of the science of "soil mechanics." The peculiar merit of this investigation is in having made clear the function of the water contents in granular masses, especially those known as clays. The equilibrium of clay depends on the viscosity of the water in the capillaries which resists its rapid escape, and also, if the surface is "dry," on the surface tension at the mouths of the capillary passages. When the passages are very small (say, one hundredth of a centimetre in diameter) the viscous resistances to flow are very large and the surface tension at the ends of the capillaries on a dry surface is sufficient to produce important mechanical effects on the mass. The speaker also described Terzaghi's "Oedometer," or consolidation apparatus for studying the behaviour of clays.

BRITISH ALUMINIUM INDUSTRY.—A new high level for aluminium production is forecast in a statement issued by the Aluminium Information Bureau. While the output of many industries in this country, it is stated, has declined from the exceptional levels of 1937, last year the aluminium industry showed a further substantial advance over the 1937 level. For example, the pig iron and steel industries of the United Kingdom showed decreases in production of about 18 per cent. in the first eleven months of the year as compared with the similar period of 1937, but the imports of bauxite were up by 18½ per cent. and the imports of unmanufactured aluminium increased by no less than 64 per cent., from 26,404 long tons to 43,413 tons. A large proportion of the aluminium used in the United Kingdom comes from Canada. The home production was 19,100 long tons in 1937 and may be roughly estimated at 22,500 tons in 1938. The imports of semi-manufactured and manufactured aluminium increased from 35,629 tons in January to November, 1937, to 39,912 tons in the same period of 1938. Exports of aluminium from the United Kingdom decreased, the figures of unmanufactured aluminium for the eleven-month period being 1309 tons in 1938 against 3693 tons in 1937, while exports of semi-manufactured and manufactured aluminium were 4346 tons in 1938 against 6116 tons in 1937.

SIR GEORGE BEILBY MEMORIAL AWARDS.—The administrators of the Beilby Memorial Fund have announced awards of 100 guineas each to Dr. F. P. Bowden and Dr. B. Jones. Dr. Bowden was educated at the Hutchins School, Hobart, and at the University of Tasmania, where he later began research work on electro-chemical problems with Professor A. L. McAulay. He went to Cambridge in 1927, entered Gonville and Caius College, and continued electro-chemical work in the laboratory of physical chemistry. In 1931 he was elected to a Research Fellowship at Caius College, and was later elected to an Official Fellowship and appointed Director of Studies and College Lecturer. In 1937 he was appointed to the Humphrey Owen Jones Lectureship in Physical Chemistry. His electro-chemical work has been mainly on over-potential and the mechanism of electro-deposition. His other work on the physical properties of surfaces has an important bearing on the problems of friction, lubrication, and wear. Dr. B. Jones studied metallurgy from 1919 to 1922 at the University College, Cardiff. From 1927 to 1929 he was attached to the metallurgical branch of the Research Department of Woolwich Arsenal, and subsequently was appointed Lecturer in Metallurgy at University College, Cardiff. Dr. Jones has devised many methods in metallurgical analyses, and his outstanding published work was on the subject of the nitrogen-hardening and on the heat treatment of steels in the "Transactions" of the Iron and Steel Institute.

Air and Water

THE NATIONAL MARITIME MUSEUM.—The first annual report of the trustees of the National Maritime Museum at Greenwich states that there were 2870 additions to the collections during the year.

PROPOSED NEW CROSS-CHANNEL BOAT.—At a recent luncheon Mr. R. P. Biddle, the Southern Railway Company's docks and marine manager, said that the company has called for tenders for a new cross-Channel boat for the Dover and Calais service.

CLYDESIDE DERELICT SHIPYARD FOR ARMS FACTORY.—A Royal Ordnance Factory is to be established at Dalmuir on the site of the yard of William Beardmore and Co., Ltd., which was acquired and dismantled by the National Shipbuilders' Security, Ltd., during the last shipbuilding slump.

DEATH OF MR. R. LESLIE.—Many members of the shipbuilding and shipping industry will regret to hear of the death of Mr. Robert Leslie, the late chief superintending engineer of the Peninsular and Oriental Steam Navigation Company. He retired in 1926 and was succeeded by Mr. R. T. Clarke.

SUEZ CANAL TRAFFIC.—During the first nine months of last year goods traffic passing through the Suez Canal amounted to 21,638,000 tons, a reduction of 3,065,000 tons on the corresponding period of 1937. The north to south traffic amounted to 5,780,000 tons, and the south to north traffic 15,848,000 tons.

PANAMA CANAL TRAFFIC.—During the year ended June 30th, 1938, 5524 ships, carrying 27,385,900 tons of cargo, passed through the Panama Canal, and paid nearly 23,170,000 dollars in dues. A report states that since the Canal was opened, 98,514 ships, carrying over 470,924,000 tons of cargo, have passed through. The dues paid total more than 429 million dollars.

THE LOSS OF THE "STOCKHOLM."—It is stated that the fire which destroyed the 28,000-ton motorship "Stockholm," at Monfalcone was caused by a short circuit. The ship was being built for the Swedish-American Line. The flames, shortly after the fire began, reached drums of highly inflammable varnish and a strong wind helped to spread them. Only the hull of the ship remains, and it is expected that a substitute vessel will be built by the company.

P. & O. LINE SUPERINTENDENT ENGINEER.—At the end of December, Mr. R. T. Clarke, the superintendent engineer of the P. & O. Line, retired, after having been with the company since 1889 and holding the post which he has left since 1926. Consequent on the retirement of Mr. Clarke, Mr. David Goodsir and Mr. Sydney A. Smith have been appointed superintendent engineers. Mr. Goodsir will be in charge of maintenance and personnel, and Mr. Smith will be responsible for new construction.

TYNE DOCK IMPROVEMENTS.—Work is shortly to begin on the construction and equipment of the proposed new quay in the north-west corner of Tyne Dock. The work will involve four separate contracts, the first of which will cover the construction of a reinforced concrete quay, 945ft. long and 51ft. 6in. wide. An area of 1½ acres is to be reclaimed, upon which will be laid four lines of railways, electric travelling cranes, &c. The area at the side of the new quay will be dredged to give a depth of 35ft. of water at high tide.

IMPERIAL AIRWAYS IN 1938.—At the end of 1938 Imperial Airways had in operation or under construction seventy-seven powerful multi-engined air liners, developing a total of just on 200,000 H.P. During its first twelve months of operation (1924–25) the company's aircraft flew 853,042 miles. During the twelve monthly period for which figures are available (1937–38) the company's air liners flew 6,223,968 miles. The traffic ton-mile figure has increased from 391,032 in 1924–25 to 8,353,618 in 1937–38. By the end of 1938 the routes operated by the company and its subsidiary and associated companies stood at approximately 30,000 miles.

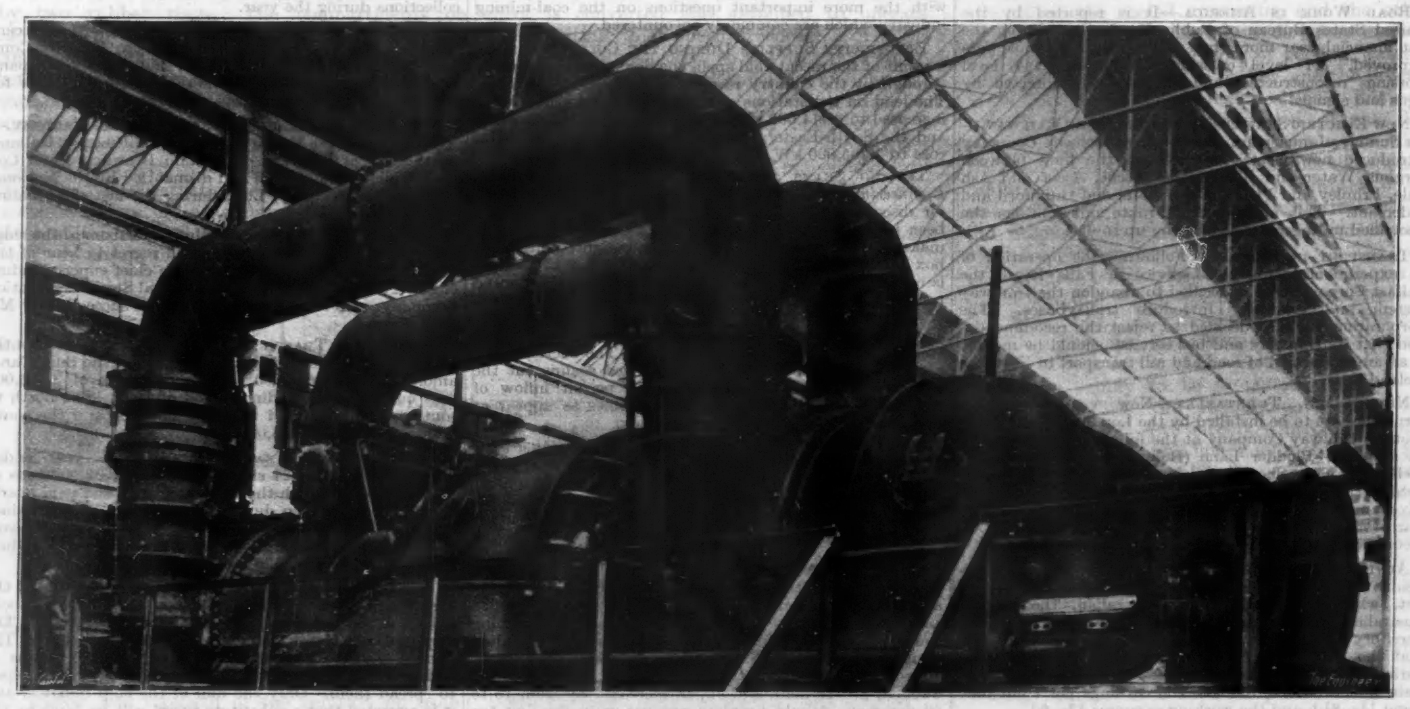
THE LIFEBOAT SERVICE IN 1938.—During last year boats of the Royal National Lifeboat Institution were launched 483 times and saved or helped to save eighty-eight ships from destruction. The lifeboats also helped another 250 vessels and boats in various ways. The number of lives saved during the year was 673. Thirty-seven motor lifeboats were being built during the year, the largest number there has ever been in one year. Twelve of the thirty-seven were completed, and the remainder will be completed during 1939. There are now 140 motor lifeboats and 24 pulling and sailing lifeboats round the coasts of Great Britain and Ireland.

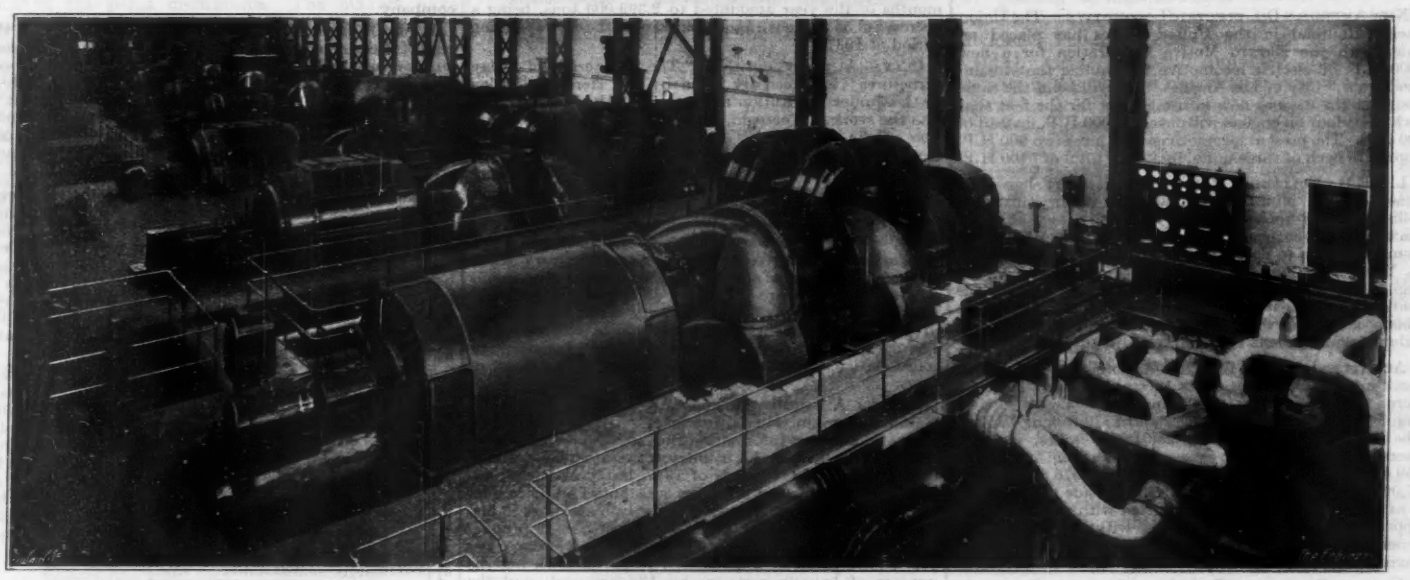
BRITISH SHIPBUILDING.—In an article in *Lloyd's List and Shipping Gazette*, Mr. F. C. Pyman, the President of the Shipbuilding Employers' Federation, discusses the state of the British shipbuilding industry. He says that if during the next ten years our shipyards were to build no more than the amount built during the past ten years, the tonnage owned by the United Kingdom would decline from its present total of 17,750,000 to about 11,000,000. He considers that our shipyards would have to produce not less than 1,250,000 tons a year over the next ten years to maintain the fleet at its present diminished level. Orders placed have fallen from 1,091,000 tons in 1936 to less than 300,000 tons last year.

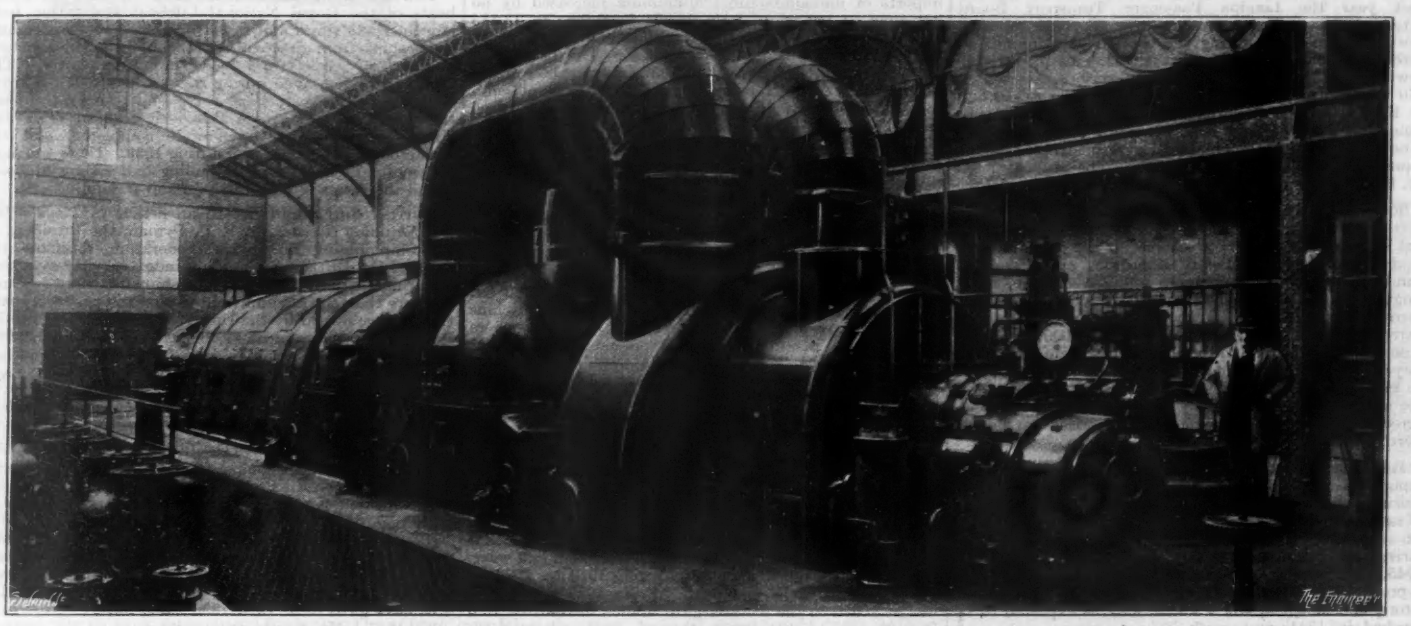
SHIPBUILDING STATISTICS.—In an article on British shipping and foreign competition in the *Shipping World*, Mr. W. A. Souter, the President of the Chamber of Shipping of the United Kingdom, gives some interesting statistics with regard to the ships built for British owners since 1910. In an analysis of the shipbuilding figures in this country for United Kingdom and Empire overseas owners, it is shown that an average of 1,335,482 gross tons per annum were built in the period 1910–1914; 1,023,674 gross tons, 1926–1930; and 551,244 gross tons, 1933–1937. Mr. Souter points out that as the wastage of our tonnage by marine losses, breaking up and sales abroad is fairly constant, it seems obvious now that we appear to have commenced a new depression, when shipbuilding from previous experience will be on a reduced scale, and that a further decline in our tonnage will take place in the next few years unless steps are taken to prevent it.

ELECTRICAL ENGINEERING IN 1938

(For description see page 31)

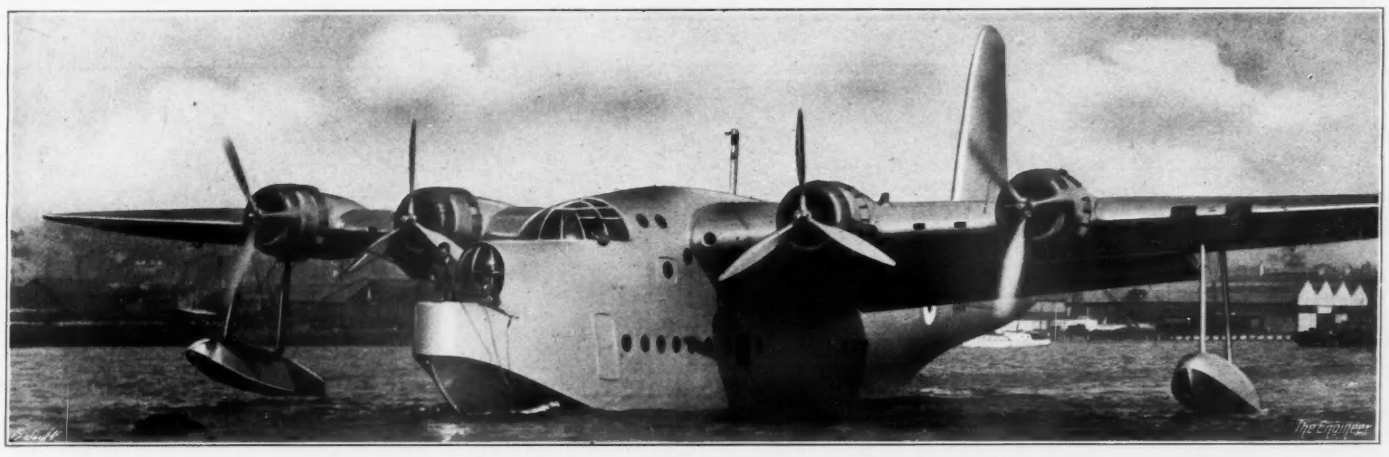


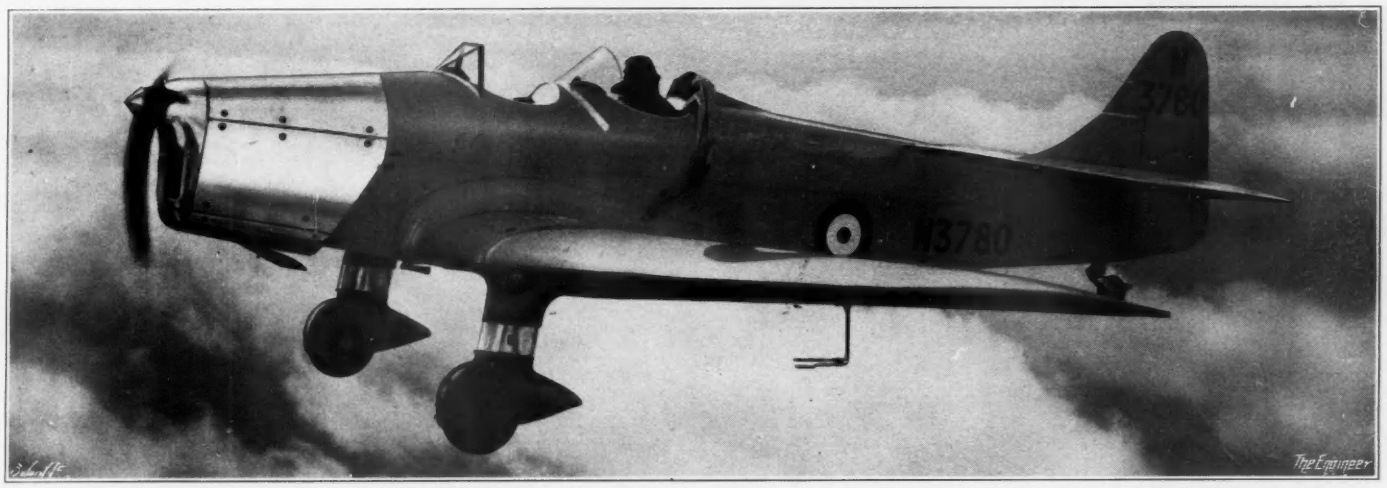




50,000-KW TURBO-GENERATOR FOR THE IRONBRIDGE STATION
TURBINE ROOM AT THE THORPE POWER STATION
LOW PRESSURE UNIT OF 54,000-KW TURBO-GENERATOR AT THE BRIMSDOWN STATION

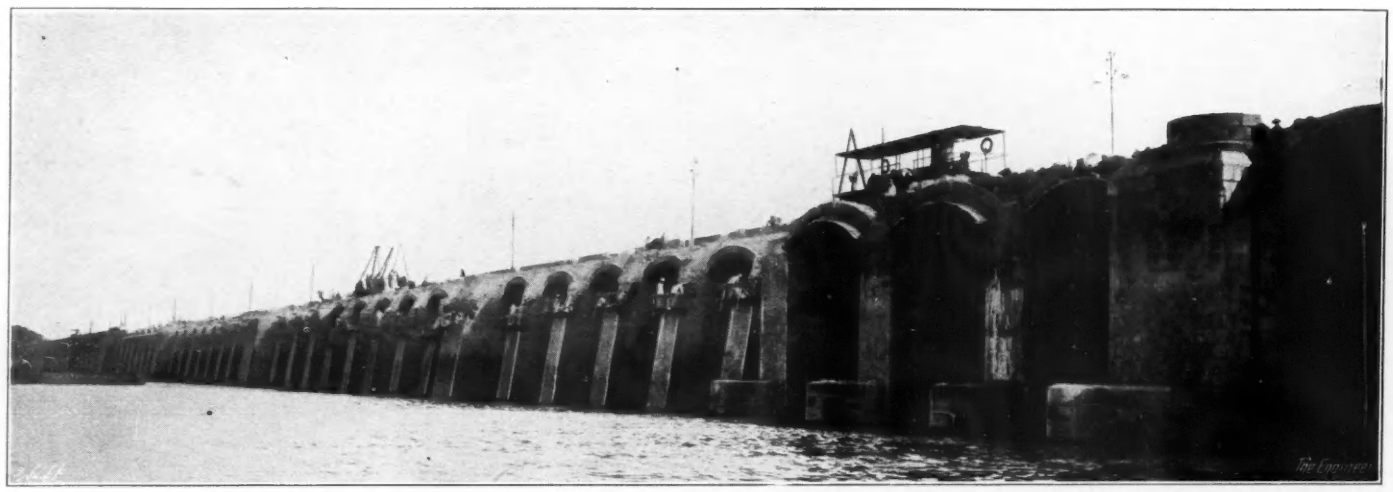
SOME AIRCRAFT OF 1938

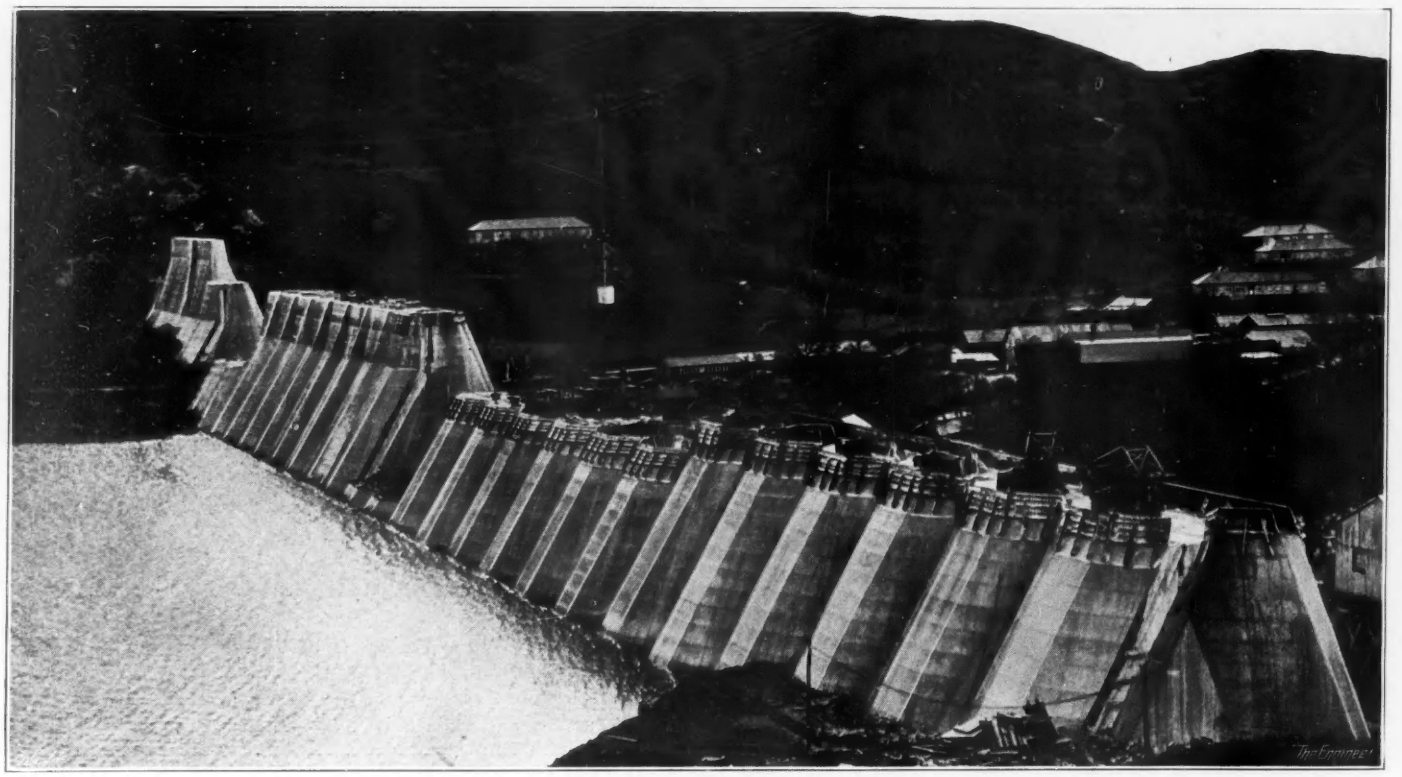




"Cygnet" All-Metal Light Monoplane—General Aircraft
"Sunderland" Flying Boat—Short Brothers
Miles "Magister" Trainer—Phillips and Powis
"Hampden" Medium Bomber—Handley Page

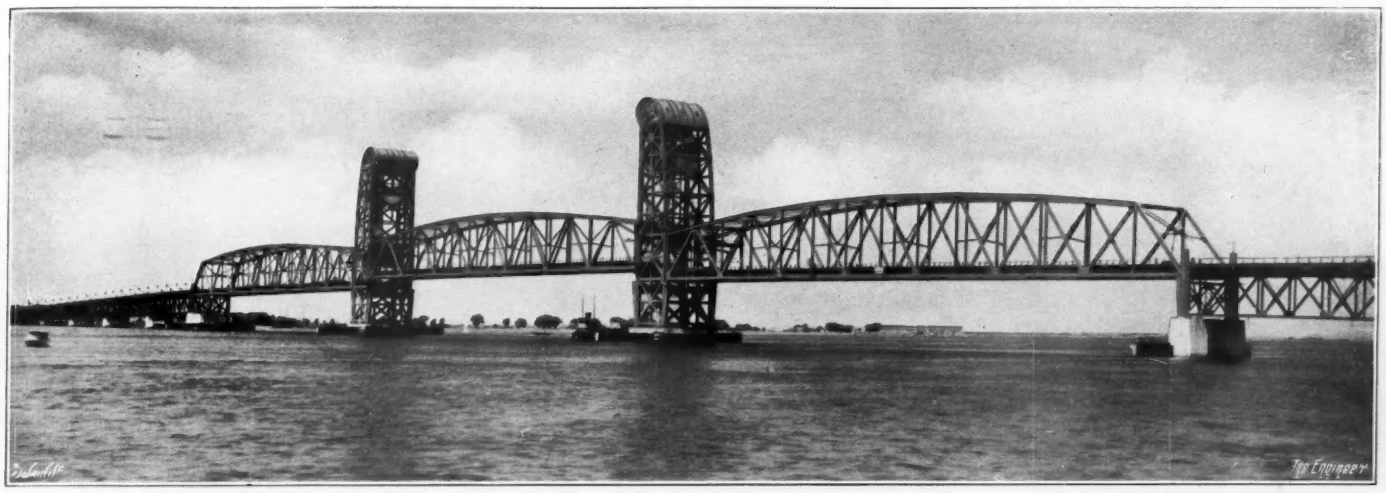
CIVIL ENGINEERING WORKS IN 1938





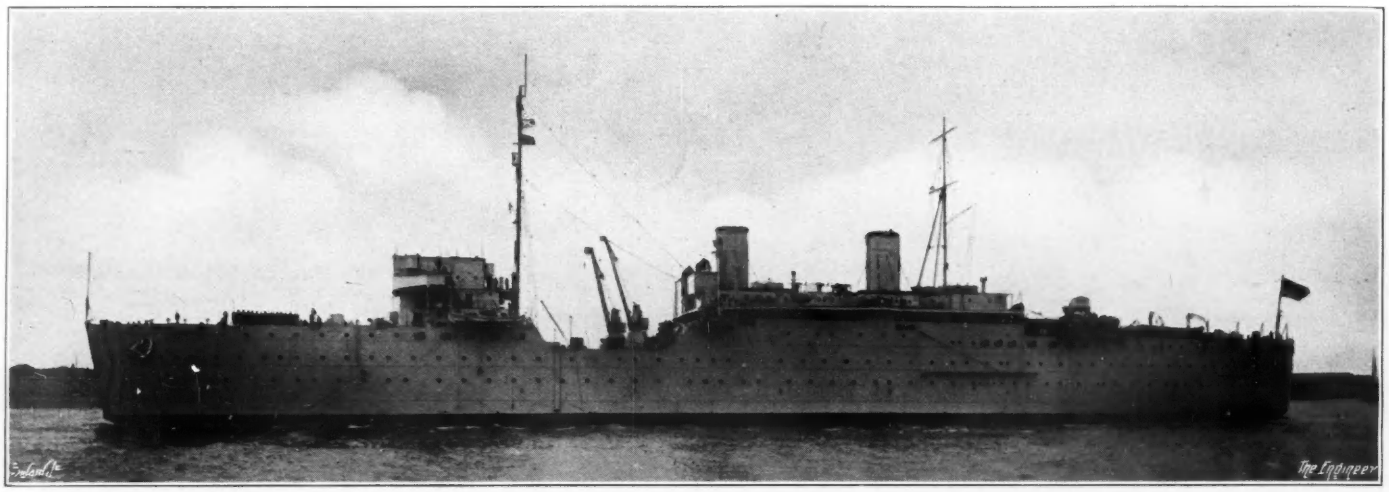
Reconstruction of Assiut Barrage, Egypt
East London Harbour, South Africa
Haweswater Dam, Great Britain

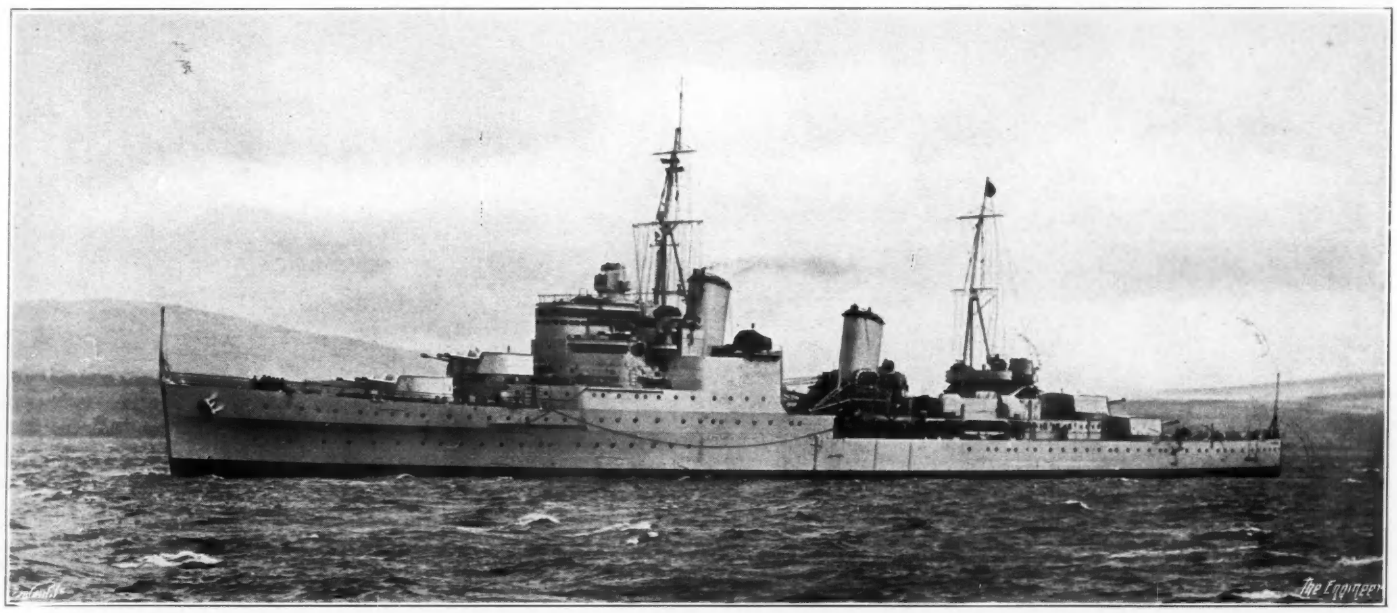
SOME BRIDGES DURING 1938

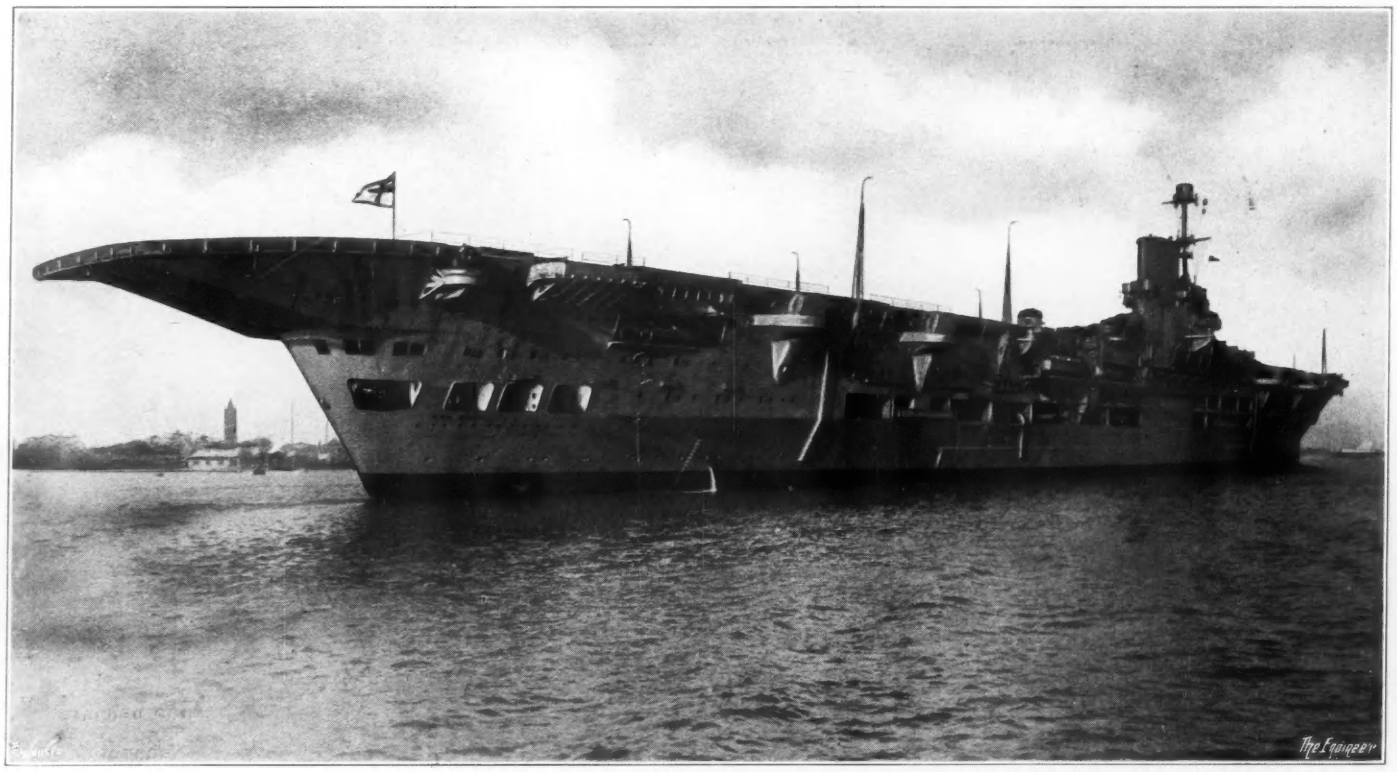


MARINE PARKWAY BRIDGE, NEW YORK, OVER ROCKAWAY INLET
ERECTION OF WATERLOO BRIDGE, LONDON, OVER RIVER THAMES
CANADIAN SECTION OF THOUSAND ISLANDS BRIDGE OVER ST. LAWRENCE RIVER

BRITISH WARSHIPS OF 1938

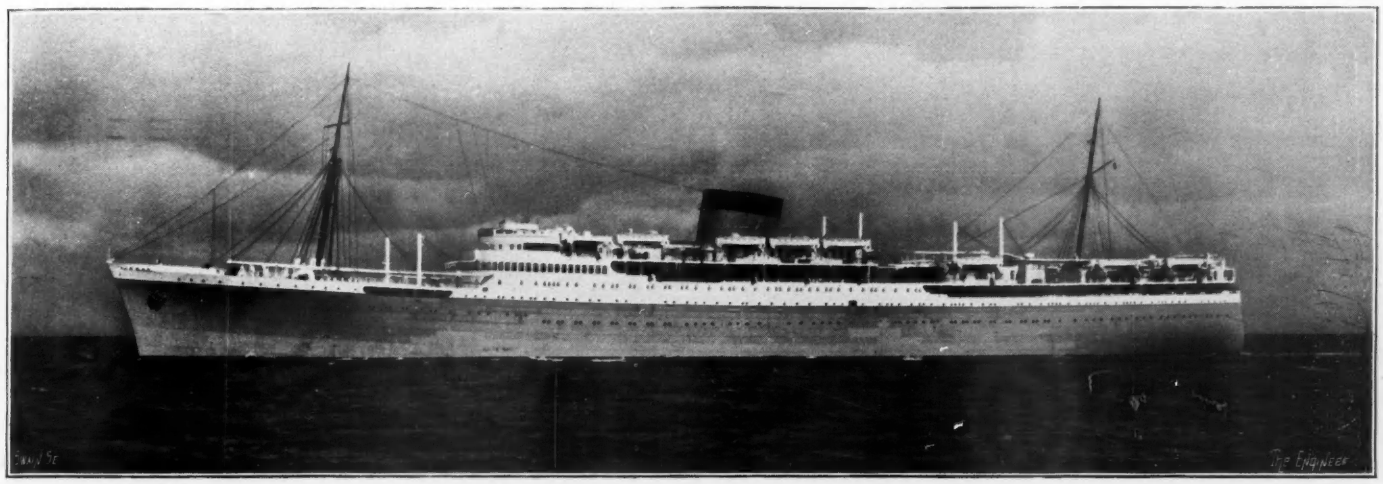


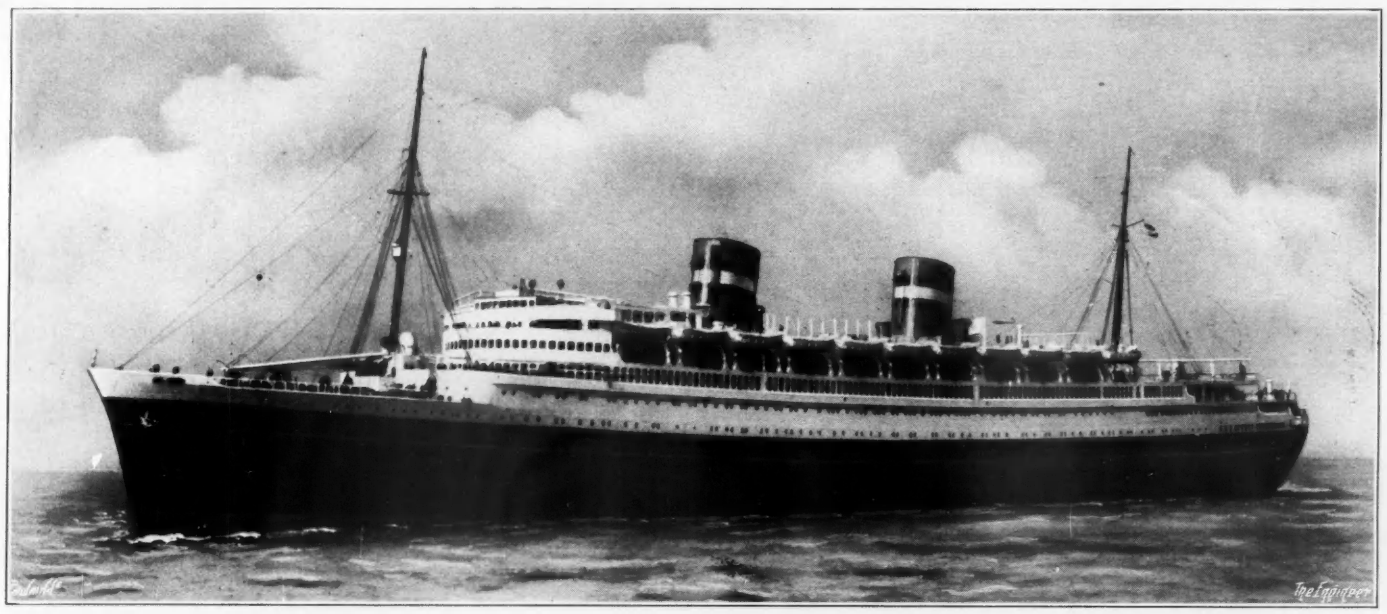


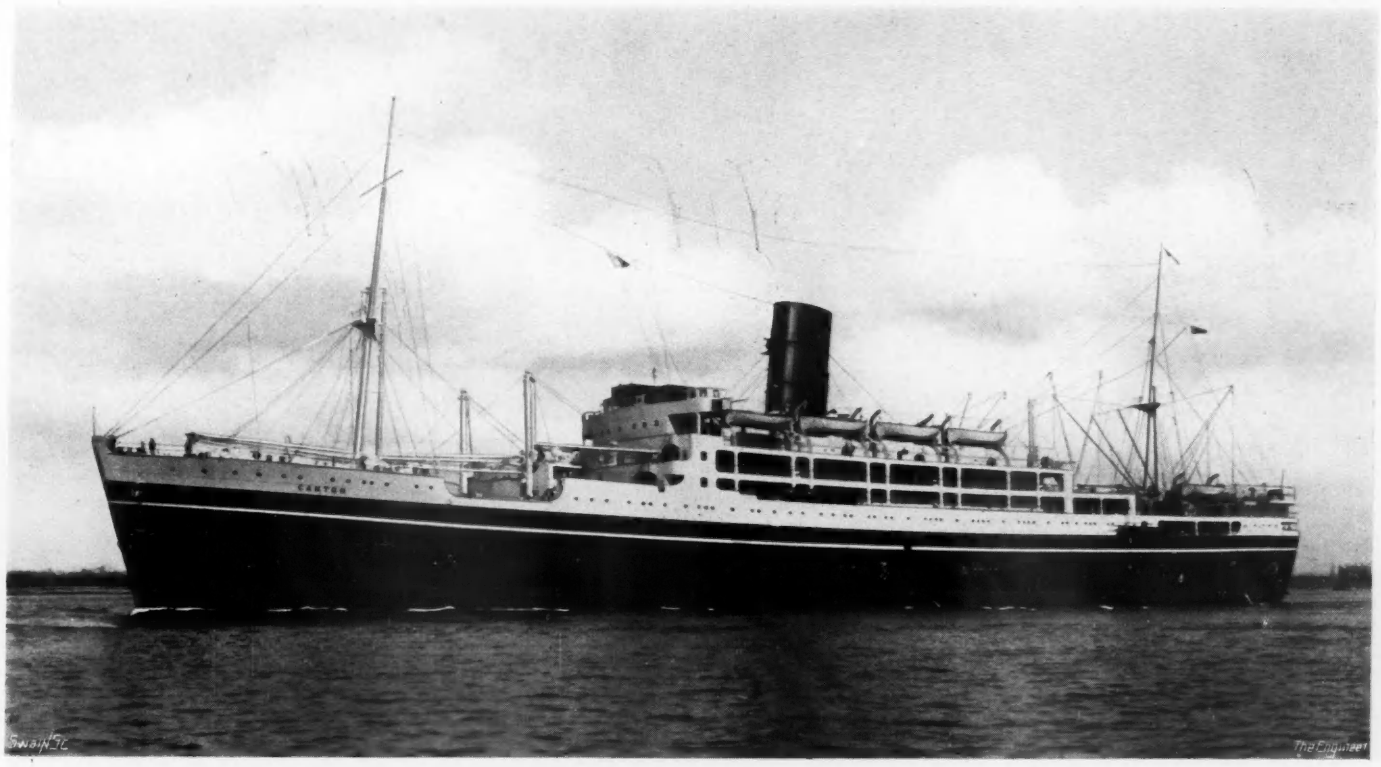


H.M. SUBMARINE DEPOT SHIP "MAIDSTONE"
H.M. CRUISER "LIVERPOOL"
H.M. AIRCRAFT CARRIER "ARK ROYAL"

SOME LINERS OF 1938

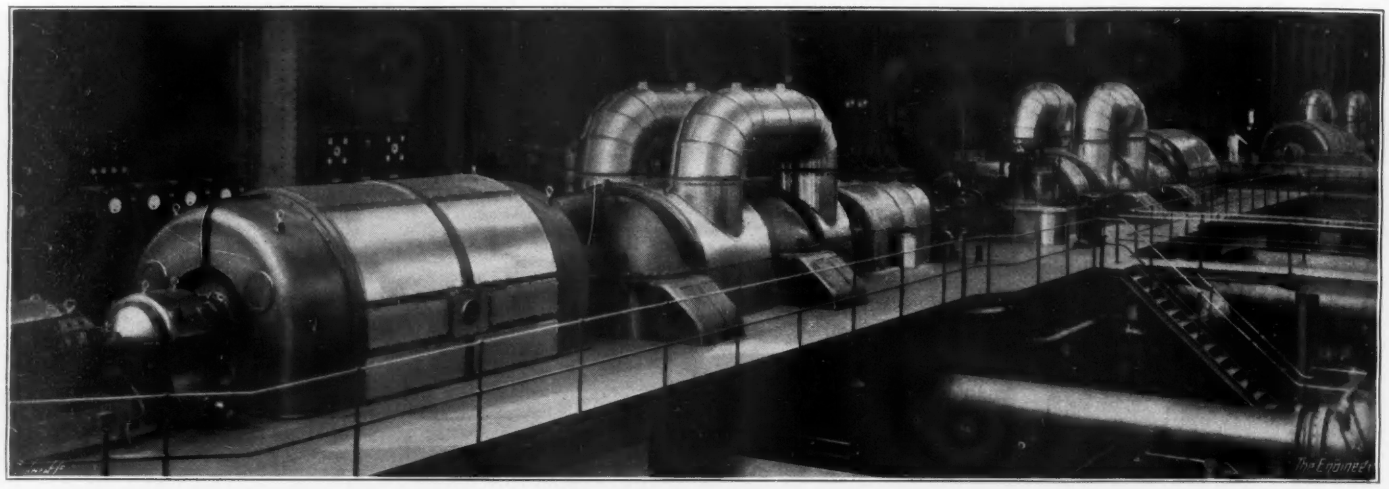


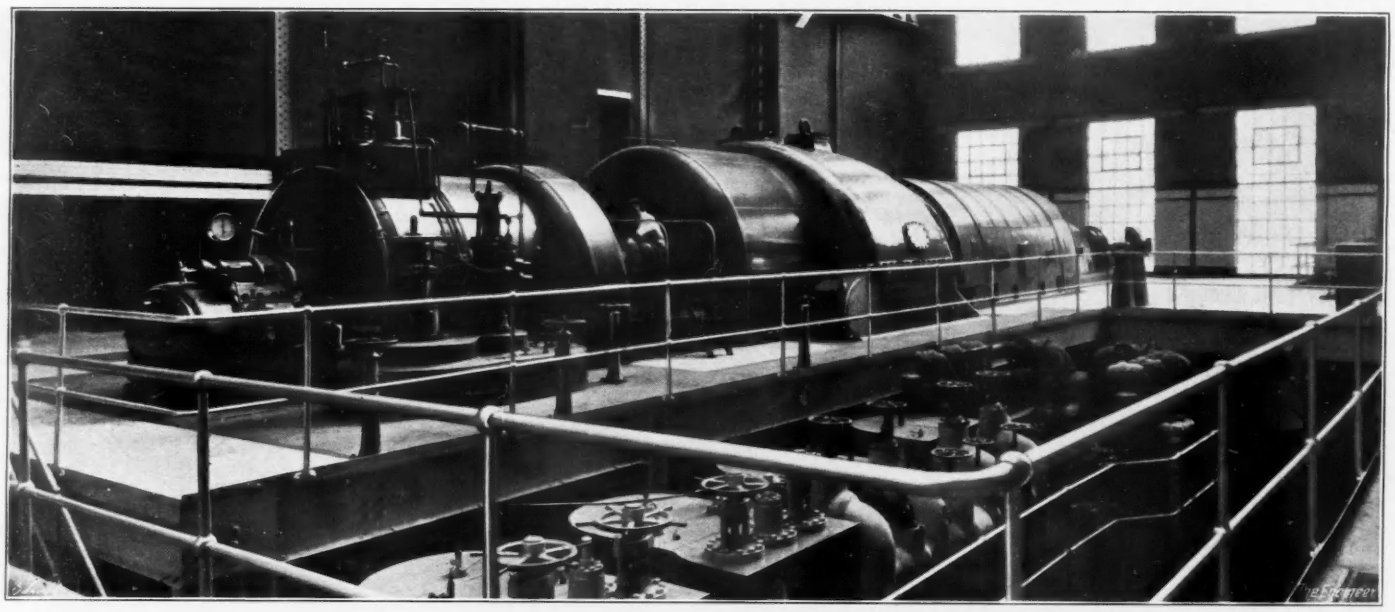


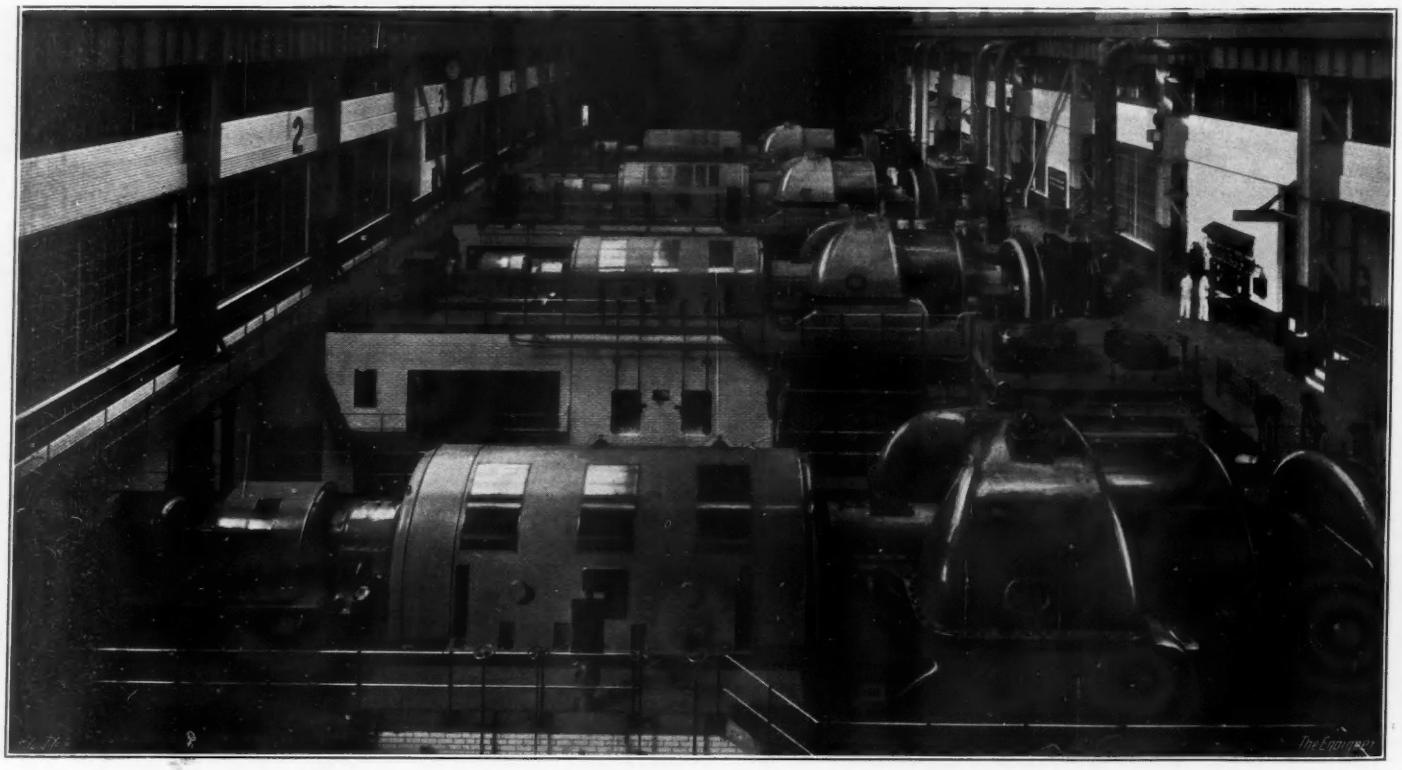


UNION-CASTLE MOTOR LINER "CAPETOWN CASTLE"
HOLLAND-AMERICA LINER "NIEUW AMSTERDAM"
PENINSULAR AND ORIENT LINER "CANTON"

ELECTRICAL ENGINEERING IN 1938

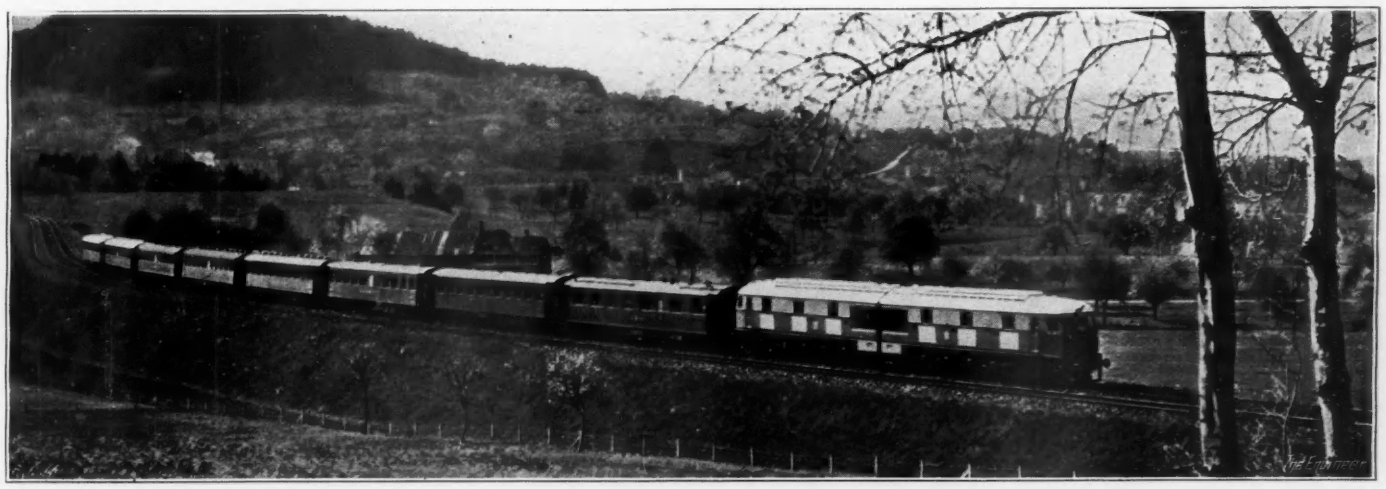


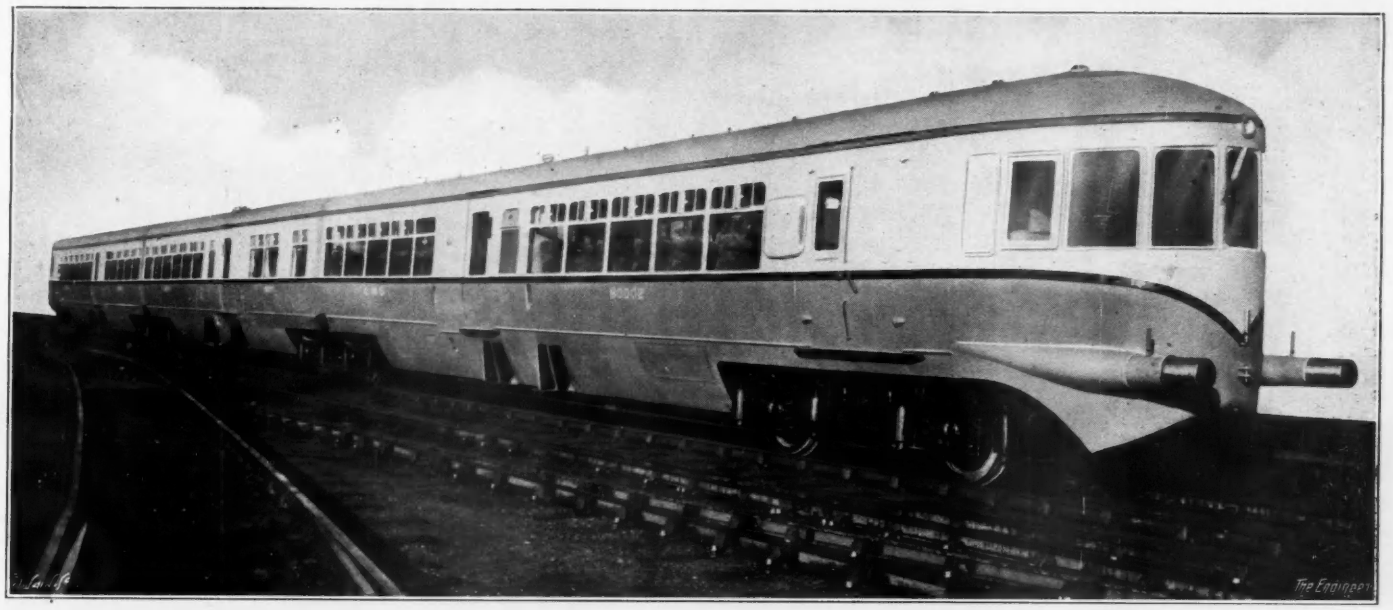




25,000 AND 30,000-KW TURBO-GENERATORS AT THE BLACKBURN MEADOWS STATION
51,500-KW TURBO-GENERATOR AT THE BARTON STATION
50,000-KW TURBO-GENERATORS AT THE CLARENCE DOCK STATION

OIL-ENGINED TRAINS OF 1938



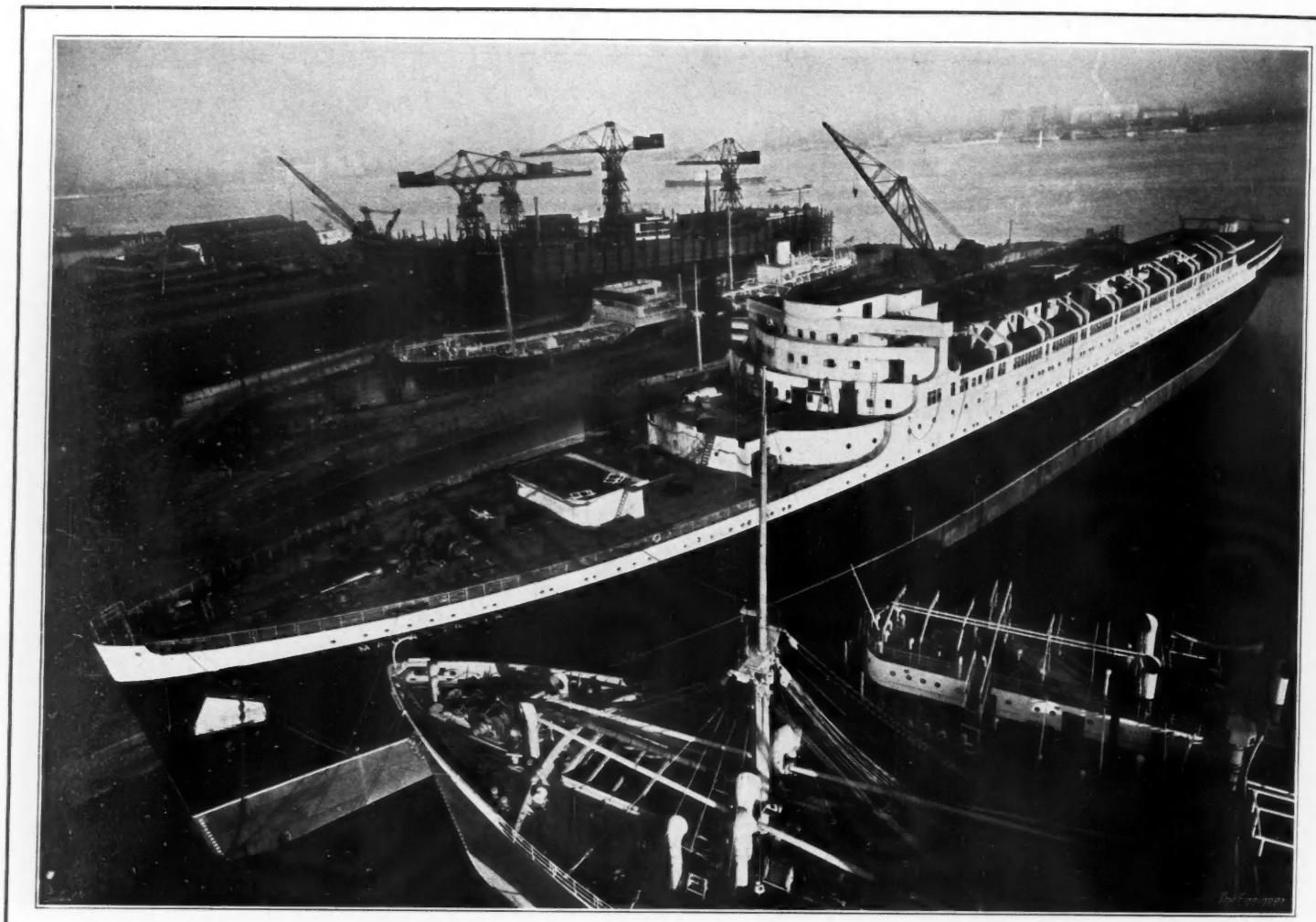


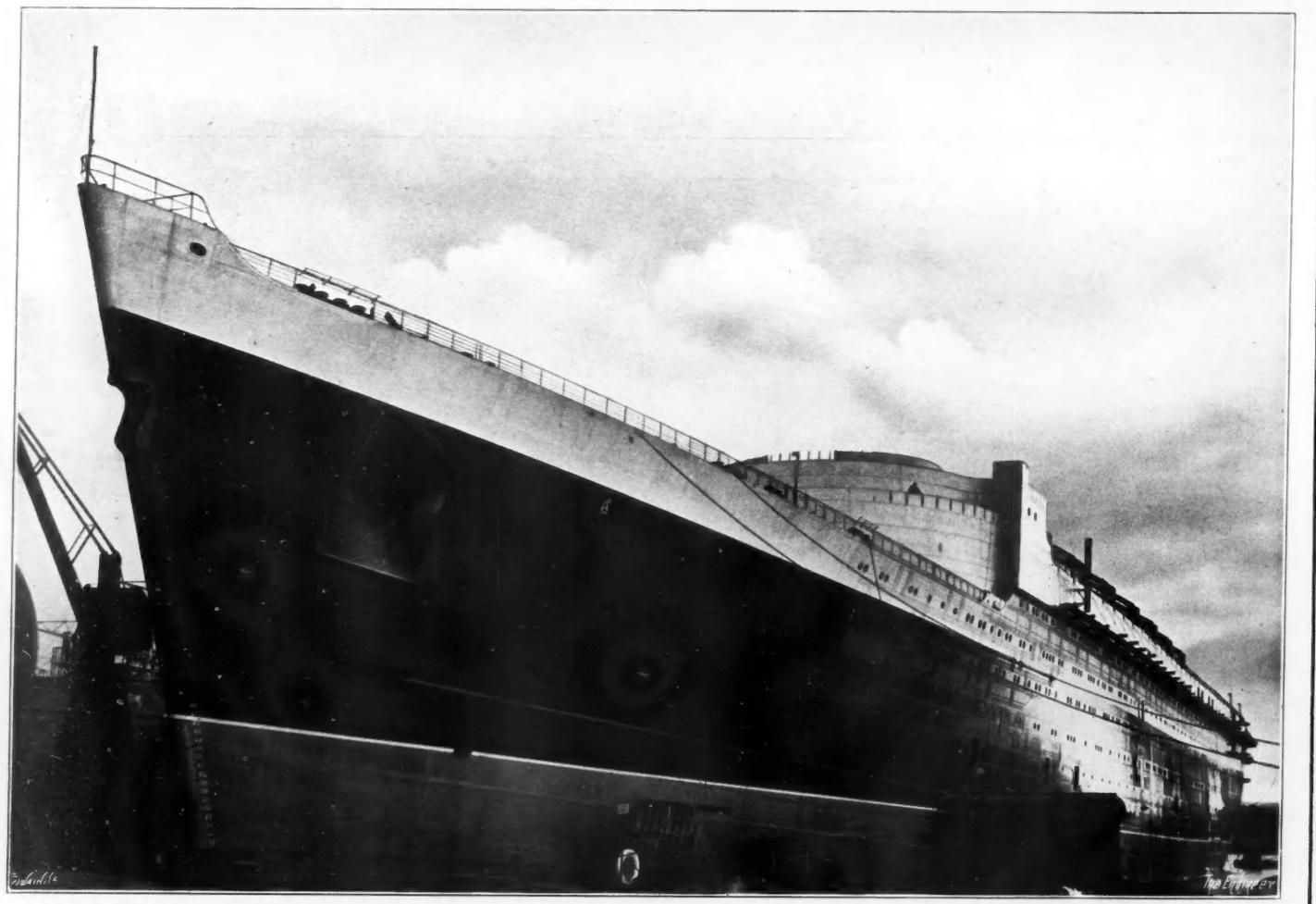
4400 B.H.P. OIL-ELECTRIC LOCOMOTIVE FOR THE ROUMANIAN STATE RAILWAYS

750 B.H.P. ARTICULATED THREE-CAR OIL-ENGINED TRAIN FOR THE L.M.S. RAILWAY

400 B.H.P. ARTICULATED FOUR-CAR OIL-ELECTRIC TRAIN FOR THE CEYLON GOVERNMENT RAILWAYS

TWO NOTABLE BRITISH LINERS OF 1938





CUNARD-WHITE STAR LINER "MAURETANIA"
CUNARD-WHITE STAR LINER "QUEEN ELIZABETH"

The Engineer

JANUARY 6, 1939

VOL. CLXVII No. 4330

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A CHANGE OF TYPE

It is the constant endeavour of this paper not only to give its readers the latest and best information about engineering events, but to present it in an attractive and convenient form. In the pursuit of this object, the size of the type of all major articles has now been increased, with the result that our pages will be even more legible than heretofore. We are confident that readers will appreciate this change, for, odd as it may seem, the world which pored over small type when lighting was bad, now, when both natural and artificial lighting is far better, requires type of clearer face and larger size. We may add that whilst the type is being enlarged there is no intention to reduce proportionately the amount of reading matter.

A Retrospect

IN millions of homes gas masks stand upon the shelf, and the faces of our parks and playing fields are scored with trenches. These things have put a stigma upon 1938 that will never be obliterated. They are the outward and visible symbols of the anxieties of the whole people for several weeks. Millions of citizens lived in daily dread of a war that they had been led to believe would mean little less than the complete destruction of the whole fabric of civilisation. Whilst it is certain that the nervous strain which the country thus endured was greatly injurious, there is little or no reason to believe that it had an equivalent value in inciting it to prepare for war. We do not suggest that a free democracy should be kept in a state of ignorance, but we do very seriously suggest that essential news should be presented calmly and not with an intention to excite or arouse. That is not a matter for the daily Press alone, but for all those, and their name must be legion, who whispered in corners private news of an alarming and disturbing nature. In correcting such faults the logical and analytical mind of the engineer, applied critically to evidence, may do much to bring alarmist reports into their correct perspective.

Looking back now, after the passage of several months, upon Mr. Chamberlain's action and the compact of Munich, we see nothing to regret. There was never at any time a doubt that had war opened, Germany would have been defeated. But the ultimate victory of the Allies, even had it taken ten years to achieve, would not have brought a stable peace to Europe. Nor would such a military demonstration of power as would have arrested Nazi aggressiveness have been more effective. The path of war is not the road to peace. Peace must be sought in mutual good will, the adjustment of differences by consultation, and the recognition of each other's difficulties and aspirations. It is on that course of appeasement that Mr. Chamberlain has endeavoured to lay Europe. It is said by many that it is fruitless to meet arrogant dictators in that vein. But patience may have its reward. Totalitarian states are the children of revolution. In countries which are torn by dissension the dictator is a necessity. The popular and democratic vote is unable to settle anything. No party will allow another to act; and none will adopt even the best and most desirable things proposed by the others. But if one man can dominate all, much may be achieved. Order may be brought out of chaos and discipline out of mutiny. That, we suggest, is why Mussolini, Hitler, and Kemal Ataturk succeeded. But autocracy is a temporary expedient. It will not be tolerated in perpetuity. The universal human love of liberty of thought and speech will prevail. The reign of the demigods having served its purpose, will come to an end and some form of democracy will be adopted. Believing, as we do, that such will be the course of events in Europe, we hold that war should be held at bay by any reasonable means short of dishonour. If it can be delayed for ten, fifteen, possibly twenty years more it may be averted for ever.

Engineers and War

To the scientifically minded, war appears as an anachronism; a survival of that element of human nature which derives from its remote semi-intelligent ancestry. Recognising, as it is forced to do, that man is a bellicose animal, prone to fighting, Science, in the large sense, yet believes that it should be possible in an age of reason to outbalance forces favouring war with forces directed towards the settlement of international disputes by logical considerations. At the present moment, however, the latter forces have no cohesion; whilst the former are often so concentrated that they are contained within the bosom of one man. By his voice, and his alone, the issue between War and Peace is decided. A feeling, we believe, is growing that the general intelligence of the nations should be vocal when matters of such terrific import must be decided. In ancient and even fairly modern times, whilst wars were prosecuted by professional armies, the interest of the people as a whole in them was limited. But now that the whole population of great nations is involved, either actively or passively, it is natural that a desire to restrain the activities of bellicose small groups or individuals should exist.

It must be observed that the collaboration of the forces opposed to war for the settlement of international disputes would be fruitless as long as it was effective in one nation alone. The need is the existence of a world-wide spirit for the maintenance of peaceful conditions. What is required is that large masses of intelligent people, drawn from all the civilised nations of the world, should amalgamate to form a perpetual frontier against the levying of war. The League of Nations attempted to set up such a frontier by diplomatic means. It failed because it was still the arena for the individual and the politician, and because every nation in the world is prepared to leave the most terrible of all decisions in the hands of a few statesmen. To make the League effective the Will to Peace must become a moral force of great magnitude permeating all the nations of the earth.

Can such a Will to Peace be engendered? There is a growing belief that it can. In the course of his Elihu Root Lecture, delivered in Washington a few weeks ago, Sir Richard Gregory said: "It is being widely recognised that science cannot be divorced from ethics, or rightly absolve itself from the human responsibilities in the application of its discoveries to destructive purposes in war or economic disturbances in times of peace. Men of science can no longer stand aside from the social and political questions involved in the structure which has been built up from the materials provided by them, and which their discoveries may be used to destroy. It is their duty to assist in the establishment of a rational harmonious social order out of the welter of human conflicts into which the world has been thrown through the prostitution of the rich gifts with which they have endowed the human race. Science has made the world one through the facilities of transport and communication now available; and it recognises no political or racial boundaries in the fields of knowledge. By the wise use of this knowledge, the earth could indeed become a celestial dwelling-place instead of a world of dust and ashes which prevailing conditions seem to be making its destiny." It is appropriate to recall here that there already exists an organisation entitled the International Peace Campaign of which one section is composed of scientific people.

We hope that Sir Richard will allow engineers to be comprised under the general title "Men of Science." In any case, their adhesion to the great army of scientific workers in all fields of natural knowledge would add enormously to the power of intelligent resistance to war which his observations adumbrate. It is undeniable that Science by steadfastly refusing to recognise national boundaries within her proper field enjoys the potential means of creating an international faith in the possibility of settling international affairs by logical methods. But engineering, too, is not without similar bonds of good fellowship between nations. We may cite, for example, such an organisation as the World Power Conference which periodically draws together the engineers of all countries for the discussion of problems which are common to all. If such vast conventions can be called for the purpose of debating questions of a material nature, is it too far a flight of fancy to foresee at some not too distant date an assembling of the engineers of the whole world to protest against warfare, to resolve to resist it actively and passively, and to seek by all means in their power to hasten the time when the reign of reason shall supplant the reign of force?

The Engineers' Guild

Amongst the important events of the year we place, without hesitation, the establishment of the Engineers' Guild. It is primarily, in its own words, "an association of the engineering profession concerning itself with the status and interests of the profession," but we see in it the germ of much greater things than this bare definition covers. In a statement recently issued by the Council of the Guild, the following words appear: "The Council believes that many engineers have failed to realise the influence of their profession, and although commerce, finance, and administration owe their present position to, and are largely dependent upon, engineering, yet their more agressive elements tend to an increasing extent to regard engineering as a subordinate and specialist activity, and to accord an inferior status to its practitioners. The Engineers' Guild offers the means by which the profession may gain recognition of its true place in the structure of society, by occupying which it can perform wider and greater service even than any which it has yet

rendered, with advantage to itself and yet greater advantage to the public interest." We see in this statement such a conception of the high duty which lies before engineers as leads us to believe that, under the blessing of wise administration, the Guild may become a power of incalculable value, not to the profession alone, but to the nation as a whole. It is unnecessary to stress the fact obvious to all who give the matter thought that this is the Age of the Engineer. For it is the engineer who gives body and substance to the abstract discoveries of science, and applies them for the benefit, happiness and contentment of mankind. Without him the world as we know it could not exist. Yet, hitherto, the profession has had no corporate means of insisting upon its inherent right to control in some measure the powers and forces with which it has endowed the world. It has even had to stand aside when it saw its works turned to dishonourable ends, lacking the ability to protest against the misuse or misrepresentation of its activities. It has often been brought into disrepute by the arguments of those who understanding neither its position nor its objects have condemned it as a force which is making for the unhappiness rather than the happiness of mankind. If, as we trust may happen, the Guild is able to pursue the policy adumbrated in the passage quoted above, we see no reason to doubt that engineers will enjoy a larger measure of respect than is now generally accorded to them, and that they will be able to exert in public affairs a beneficent influence.

Industry in 1938

The condition of the engineering industries last year was neither one thing nor the other. At times it was feared that another severe depression was approaching, but whilst there was a regression, it never amounted to a slump, and in certain branches of trade was inappreciable. It is of interest to reflect for a moment upon the influence of rearmament orders upon the state of trade. A common impression is that it is very great; that it is rearmament, and rearmament alone, that is averting a slump. In one sense that view is right; in another wrong. It is right because the margin between prosperity and the reverse is so small that the armament orders may turn the scale; and it is wrong in respect of the fact that, since in several industries normal production has been displaced by abnormal, the prosperity of industry might have been almost as great as it is had there been no rearmament programme. It is unfortunately by no means easy to get at reasonably representative returns for the manufacturing industries, but we have in the production of iron and steel an index which must reflect fairly accurately the general condition in engineering. From available figures it appears that, taking the whole of the iron and steel production of the kingdom, not more than 10 per cent. and probably little more than 8 per cent. is being consumed on the making of warlike stores, &c. Impressions that the proportion is very much higher are probably derived from certain centres, Hallamshire in particular, where special steels are made. In those centres the output of steel for armaments is always relatively large and there is nothing very remarkable in the fact that it now stands at 25 per cent. and over. The conclusion to which these figures lead us is that the often-heard statement that the country is living on the rearmament programme is misleading. It would appear that at least 90 per cent. of the engineering trade is of a normal character, and it may be suspected that 4 or 5 per cent. of the remainder at least could be regained were armament orders stopped.

Railways

Whilst the usual definite indications of a trade depression were never permanent nor positive throughout the year, yet the railways suffered such a diminution of traffic that on one system at least it was held expedient towards the end of the year to take a large number of trains out of the time tables. The actual significance of this depression of the railways cannot at the moment be ascertained with certainty, but it is a noteworthy fact, at least, that the falling off in receipts is not peculiar to Great Britain alone. One deduction from that fact is that the fall is not due to the state of industry, but to the competition of other modes of transport—especially road transport. It is obvious that such is the view of the railways themselves, for late in November they opened a campaign for a "Square Deal." The contention of the railways is that they are severely handicapped by the fixing of statutory rates for the transport of freight, whilst road hauliers are allowed to make such terms as they can with their customers. For some time before the companies took action it was believed that they would approach the Ministry of Transport with a request that road hauliers should be subjected to the same restrictions, but when a deputation called upon the Minister a few weeks ago the railways took the opposite course and asked that the regulations of the Railway Rates Tribunal should be withdrawn or relaxed. In other words, they did not seek to hamper the road hauliers, but they did ask to be given the same facilities for seeking business. No decision had been reached by the end of the year. There are great difficulties. It cannot be denied that the schedules of the Railway Rates Tribunal are of service to the companies in preventing cut throat competition, and it is known that they check certain undesirable practices. On the other hand, they certainly hamper the railways *vis-à-vis* road competition. If the schedules were, in fact, useful to the railways it may be argued that they would be equally useful to the roads by stopping similar abuses. But it is certain that the roads would have opposed any extension of present restrictions, limited as they are, and it is probable that the railways are beginning to feel that they have had too much of a good thing and that, despite their virtues, they would be better off without the schedules.

Iron and Steel

The steel industry is entering the New Year under more hopeful conditions than were experienced at the opening of 1938. The recession in trade had already set in at the close of 1937 and became accentuated as the late year progressed. In the first six months the market was congested with Continental steel which had been held up during the period of the shortage and which was rushed into this country by the Continental sellers in order to avoid the duty which had been suspended until the end of March. With the reimposition of the duty there was a sharp decline in the imports, but the large quantities brought into the country by consumers, and also by the steel industry itself under its scheme for the central buying of pig iron and scrap, seriously reduced the demand for new production. The decline in business reached its lowest point in August, and from then onwards there was an improvement which was reflected in higher production figures.

Prices had been stabilised at the end of 1937 until December 31st, 1938. It was not until the middle of December that prices were reconsidered and reductions announced covering the period January 1st to June 30th, 1939, ranging from 25s. on sheets to 12s. 6d. on structural material, and 7s. 6d. on basic pig iron. The prices for practically every description of iron and steel were reduced, and the foundry iron makers broke away from the policy of the rest of the trade by refusing to fix any period during which the new prices should be operative.

The British steel export trade was not maintained at such a high rate as in 1937, and whilst at the beginning of 1938 the steel makers were ahead of their quota under the Cartel arrangements, later in the year they dropped behind. Some irritation was caused by reports of price cutting by the Continental steel makers in spite of the Cartel regulations and also in the first half of the year by keen competition from American producers. At the end of June it was decided that the European Steel Cartel should be renewed for a further three years. This was partly due to the efforts of the Belgian Prime Minister who intervened to appease certain of the Belgian works which were dissatisfied with their quota. The meeting of the Cartel at which this decision was reached was noteworthy from the fact that American representatives attended and that shortly afterwards it became known that a section of the American steel industry representing about 80 per cent. had entered into an agreement with the Cartel. That part of the American industry remaining outside the agreement, however, gave considerable trouble during the greater part of the year in overseas markets.

Although the original scheme for the establishment of a steel works at Jarrow had been abandoned, the works of the new Jarrow Tube Company, Ltd., and of Jarrow Metal Industries, Ltd., were opened at the beginning of June, and work proceeded throughout 1938 upon the scheme for establishing a small steel works in that town. Apart from these enterprises there were no important developments in the establishment of new works or extending old ones, and it must be admitted that market conditions were not favourable to the carrying out of such designs.

Yesterday and To-morrow

In the many pages of this issue we endeavour to present a broad review of the progress of various branches of engineering in 1938, and in our next number we shall continue the tale. It will be seen that in nearly every direction we have found something of interest to record and in only one have we met with disappointment. As a rule we have devoted at least one page of our annual illustrated supplements to steam locomotives. But on this occasion we could not discover a single engine of outstanding characteristics that belongs properly to last year. That is true equally of foreign countries as of this. Many engines have, of course, been built by the companies and by the trade, but none of them depart notably from existing designs. On the other hand, the internal combustion engine and railway vehicle have provided a good deal of interesting, if not very exciting, matter. An event of the year in railway matters which must not be passed over was the completion of engine and train derailment tests in South Africa. These tests were illustrated and described in our issue of November 25th, 1938.

Each of our special articles opens with an introduction, and it would be merely redundant to epitomise here the comments that may be found there. Let us rather give what space remains to us to a glance at the coming year. As far as can be seen at the moment there are no indications that a severe general recession is in sight, there are even grounds for hope of improvement, but a great deal depends upon the spirit in which industry is conducted. The greatest of all needs is a resolute refusal to allow the anticipation of war to hinder peaceful activities. For months war has been an obsession, and an obsession of a very injurious kind. It is time that it was driven out of our minds. The wise man who finds it necessary to make provision against the future takes the essential steps, appoints officers to see that they are carried out, and delegates all authority to an *ad hoc* body. Having done all that he can, he then discharges the subject from his thoughts and gives his attention to other affairs. The nation will be wise to follow that common sense procedure. It should entrust the protection of the country and all warlike preparations with confidence to appointed authorities and give itself up to the pursuit of its normal vocations. Persistent fussing and nervousness over the imminence of war inevitably delay the prosecution of peaceful works, the circulation of money, and the investment of capital. It would be vain to hope for a prosperous year if that condition of mind is allowed to continue and is even encouraged in certain quarters. We do not suggest any relaxation of our efforts to be strong at sea, on the land, and in the air, or in the preparation of defences against invasion, for by such things war is made less probable. What we do is to appeal to all to give their nerves a rest, to go about their business in a calm spirit, and to act as if war was a remote contingency. If it does come, they will be none the worse for having followed that course; if it does not, they will be the better off. Crises may arise in the coming twelve months. Nothing will be gained by going out to meet them, and much will be lost.

Shipbuilding & Marine Engineering in 1938

No. I

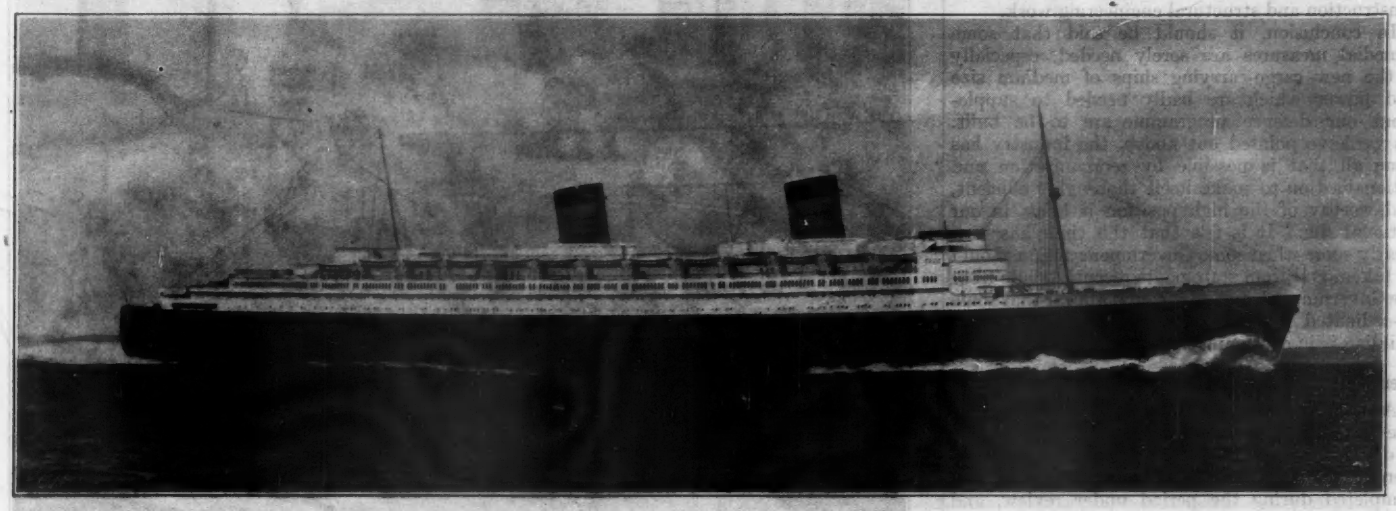
THE year which has just ended will be remembered as a period of high output with few orders. The position with which the shipbuilding and marine engineering industry is now faced is one of extreme gravity, and very different from that of a year ago, when after a busy year there was still a large amount of work in hand, both in the shipyards and the marine engineering works. With the balance of orders remaining over from 1936 and 1937, the past year, with the increased amount of naval work, was one of unusual activity, but quite early there was a diminution in the flow of new mercantile orders, which became more serious as the year advanced, and there is now an almost complete absence of liner, tanker, and cargo ship work, and little prospect of immediate improvement. It means that with the work which is already on the berths, and an optimistic estimate of merchant shipbuilding orders of, say, 300,000 gross tons, there is every possibility of the 2,000,000 gross tons annual shipbuilding capacity of British yards being at no distant date only employed to one-quarter of that capacity. The naval work in hand, which at the present time comprises about 157 ships of all types, with a total of nearly 550,000 tons displacement, to which we refer in another article, has helped to offset in some degree the enormous decline which has taken place in merchant work in the districts and yards which are equipped for this class of work. It should be borne in mind, however, that naval work only affects about 18 per cent. of the available shipbuilding berths.

Throughout 1938 the position abroad stood out in striking contrast to that of Great Britain. In 1929 it may be recalled, we were building in this country a tonnage equal to that which was being constructed in the rest of the world. In the years that have followed, owing to barter transactions in such countries as Germany and Italy, direct subsidies in such countries as Germany, Italy, America, and Japan, currency devaluation in Denmark, Sweden, and Holland, and lower production and labour costs in practically all competing countries, with the exception of America and France, the foreign total of merchant tonnage has continued to rise sharply to 1,800,000 tons, as compared with only 885,000 tons in British yards. In the first nine months of the past year foreign shipbuilders launched 1,500,000 tons of merchant work, or twice as much as the British figure of about 750,000 tons. At the end of the year these totals had risen to even higher figures. The increase in the number of ships built abroad has led to a marked drop in ships built on foreign account in British yards, which in 1929 was nearly 500,000 tons, or 30 per cent. of the merchant tonnage then building in Great Britain. To-day only 95,000 tons, or about 11 per cent. of the total being built in British yards, is for foreign owners, and this year's figures are likely to be even still lower. The loss in tanker work has played a large part in bringing about this changed position. Britain is now only constructing twenty-seven tankers compared with seventy-one similar ships which are being built abroad.

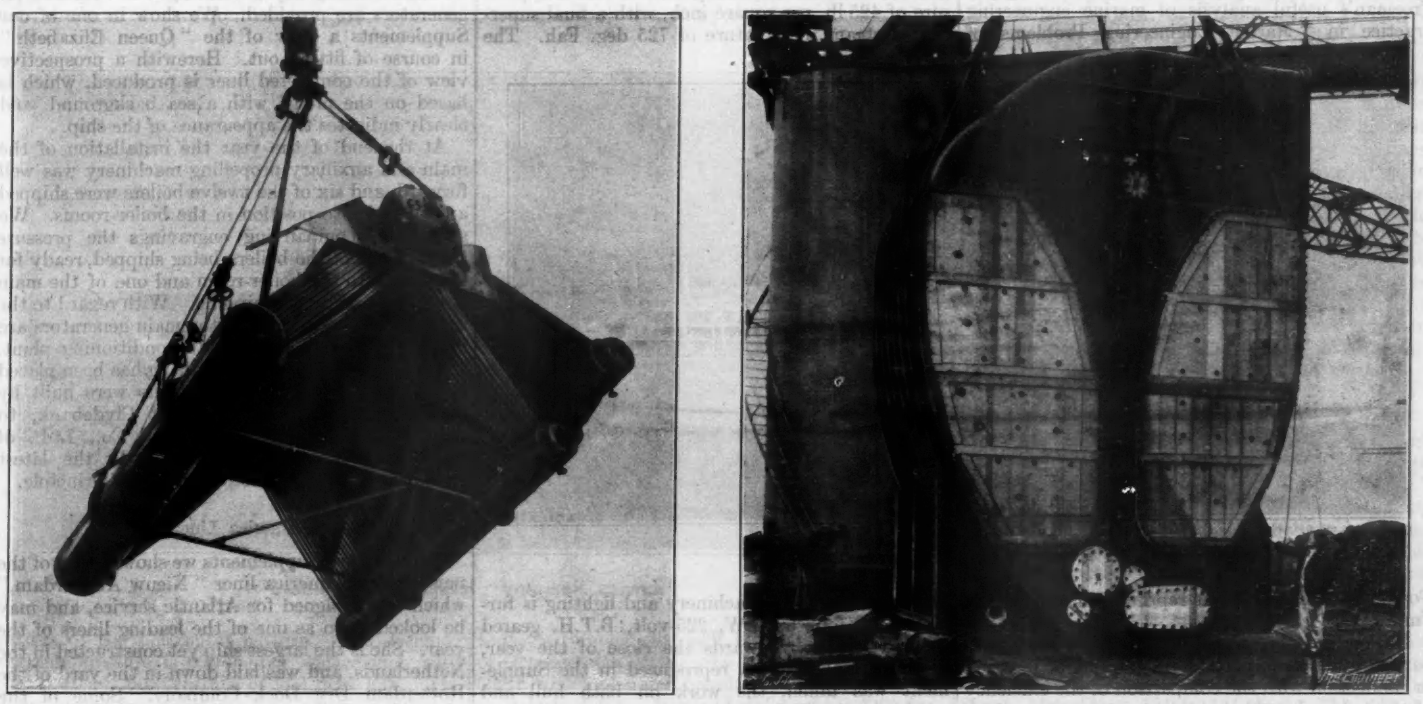
In 1930 the shipbuilders in this country decided to put their own house in order, and to reduce as far as safely possible the shipbuilding capacity by closing down all redundant shipbuilding establishments. National Shipbuilders' Security, Ltd., was formed with this object, and by its operations the original British shipbuilding capacity has now been reduced by about one-third, leaving the existing capacity equivalent to an annual output of 2,000,000 gross tons for merchant ships. Before National Shipbuilders' Security, Ltd., began its policy of rationalisation, about 1,500,000 tons of merchant shipping were under construction, and close upon 46 per cent. of the available berths were idle. In 1938, when the berth capacity had been reduced by one-third, there were about 55 per cent. of the reduced number of berths still without ships to build. The seriousness of the present position is accentuated when it is remembered that whereas in 1929 there was a negligible amount of naval work in the yards, at present naval ships aggregating close upon 550,000 tons displacement are being built in British yards, as mentioned above.

Ship repairing was subject to the same keen foreign competition with which shipbuilding was faced, and in connection with the past year there are few conversion and machinery replacements to be recorded. With falling freights, more shipping was laid up, and both shipbuilding and ship repairing suffered thereby.

Employment in the industry continued steady



CUNARD WHITE STAR LINER "QUEEN ELIZABETH"



BOILER AND CONDENSER UNITS FOR LINER "QUEEN ELIZABETH"

and without labour disturbance. A new agreement with regard to apprentices and boys was made with the shipbuilding unions. During the period under review a scheme of holidays with pay was introduced into the shipyards and engine works. The unemployment in the whole industry was roughly 20 per cent., but there is likely to be little change in employment for some time on account of the increasing numbers of men who are employed on completion work, both for vessels being built in connection with the defence programme, and now fitting out, and the completion of such large ships as the "Queen Elizabeth," the "Mauretania," and the "Dominion Monarch." One reason for the slight fall in the shipbuilding employment figures is the fact that many workers are obtaining ready employment in other industries engaged in rearmament work, such as aircraft construction and structural engineering work.

In conclusion, it should be said that some remedial measures are sorely needed, especially if the new cargo-carrying ships of medium size and power which are badly needed to supplement our defence programme are to be built. As we have pointed out above, the industry has done all that is possible by reorganisation and rationalisation to make itself thoroughly efficient, and worthy of the high position it holds in our national life. It is felt that the time has now clearly come when some Government action should be taken, and from statements recently made from the Government benches, it would appear that some co-ordinated policy for both shipping and shipbuilding is in contemplation.

Trends in Design and Construction

As might be expected in such a busy year as the one just ended, there were few outstanding advances in design and construction, other than those which were embodied in the leading ships launched and completed during the period under review, and referred to later in our articles. Trends to be noted, however, included the greater use of high-fatigue limit and other special steels for the hull and machinery construction of both naval and mercantile ships, also a wider use of steel castings, and parts fabricated by welding. These factors were fully discussed during the International Conference of Naval Architects and Marine Engineers held from June 16th to 18th in London, and the International Engineering Congress which took place in Glasgow the following week. Papers which call for mention on the shipbuilding and marine engineering sides are those of Dr. James Montgomery on "Trends in Shipbuilding," and Mr. Sterry B. Freeman's useful analysis of marine engineering practice in "Marine Engineering Problems of To-day." This paper was reprinted in our issue of June 24th.

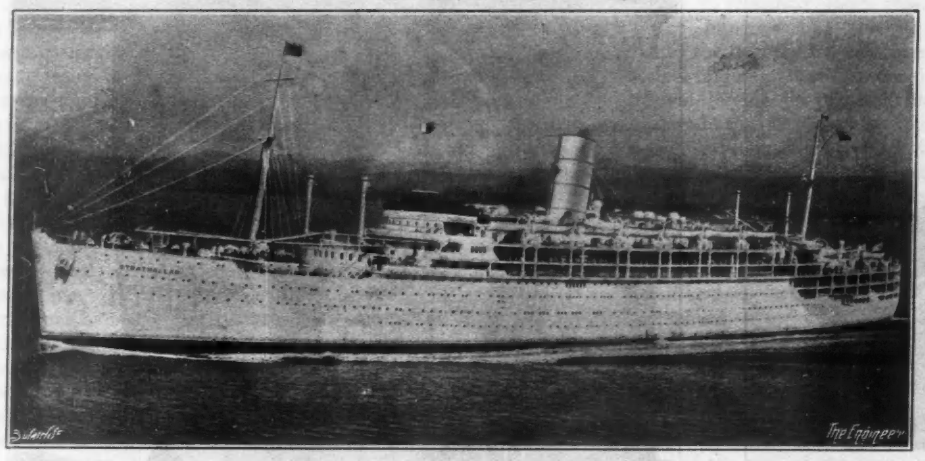
During the year the Institute of Welding embarked upon an important programme of research in connection with the comparison of the efficiency of riveted and welded ship's structures, in which work it is collaborating with the Admiralty, the Board of Trade, the shipbuilding firms, and the classification societies.

One noteworthy departure from hitherto accepted practice was the development of a new British type of streamlined rudder termed the hydrogap rudder, which we described in our issue of December 23rd.

Cunard White Star Liners

Outstanding among the work of the year was the launching and fitting out of Britain's two largest Transatlantic liners, the Cunard White Star ships "Mauretania" and "Queen Elizabeth," views of which at their fitting-out berths on the Mersey and the Clyde are included in the Supplement.

The "Mauretania" took the water at the Birkenhead yard of Cammell, Laird and Co., Ltd., on Thursday, July 28th, and the ship and her twin-screw geared turbine propelling machinery was fully described and illustrated in our issues of August 5th and 12th. She has an overall length of 772ft., with an extreme breadth of 86ft. 8in., a draught of 30ft. 9in., and a measurement of about 34,000 gross tons. The propelling machinery comprises a twin-screw arrangement of Parsons reaction, single-reduction, geared turbines, with a designed total output of about 42,000 S.H.P., sufficient for a service speed of 22½ knots and a probable trial speed of 23¼ knots. Steam is supplied by six Yarrow side-fired water-tube boilers, designed for burning oil fuel, which are arranged in two boiler-rooms. They have a working pressure of 425 lb. per square inch, with a final superheated steam temperature of 725 deg. Fah. The power for auxiliary machinery and lighting is furnished by four 800-kW, 225-volt, B.T.H. geared turbo-dynamos. Towards the close of the year, when the photograph reproduced in the Supplement was taken, the work on both hull and machinery had reached an advanced stage. The "Mauretania" is scheduled to sail on her maiden voyage from Liverpool to New York in June.



P. AND O. LINER "STRATHALLAN"

TURBINE MACHINERY FOR P. AND O. LINER "STRATHALLAN"

The most notable event in the shipbuilding world during 1938 was undoubtedly the successful launching of the Cunard White Star liner "Queen Elizabeth" from the Clydebank yard of John Brown and Co., Ltd., on Tuesday, September 27th, when the naming ceremony was performed by Her Majesty the Queen. In our three articles of September 23rd and 30th and October 7th we described the principal features of the hull and machinery, and also the launching ceremony. Some of the particulars may be recalled. The ship has a length of 1030ft., with a beam of 118ft., and a depth to the top of the lounge structure of 120ft. The measurement will be close upon 85,000 gross tons. The propelling machinery, which in output will exceed, it is expected, that of the "Queen Mary," namely, 180,000 S.H.P., will consist of four sets of Parsons reaction, single-reduction geared turbines. There are four turbines in each set, comprising an H.P. turbine, first I.P., second I.P., and L.P. The boilers are arranged in four rooms, three in each room, and are of the latest Yarrow side-fired oil fuel type, with a designed working pressure of 425 lb. per square inch, and a final steam temperature of 750 deg. Fah. The auxiliary generating sets consist of four B.T.H. geared turbo-dynamos, each with a designed output of 2200 kW at 225 volts, designed to take steam at full boiler temperature and 390 lb. per square inch pressure. Two Mirrlees 133 B.H.P. oil engine emergency generating sets with B.T.H. generators are provided. We show in one of our Supplements a view of the "Queen Elizabeth" in course of fitting out. Herewith a prospective view of the completed liner is produced, which is based on the model with a sea background, and clearly indicates the appearance of the ship.

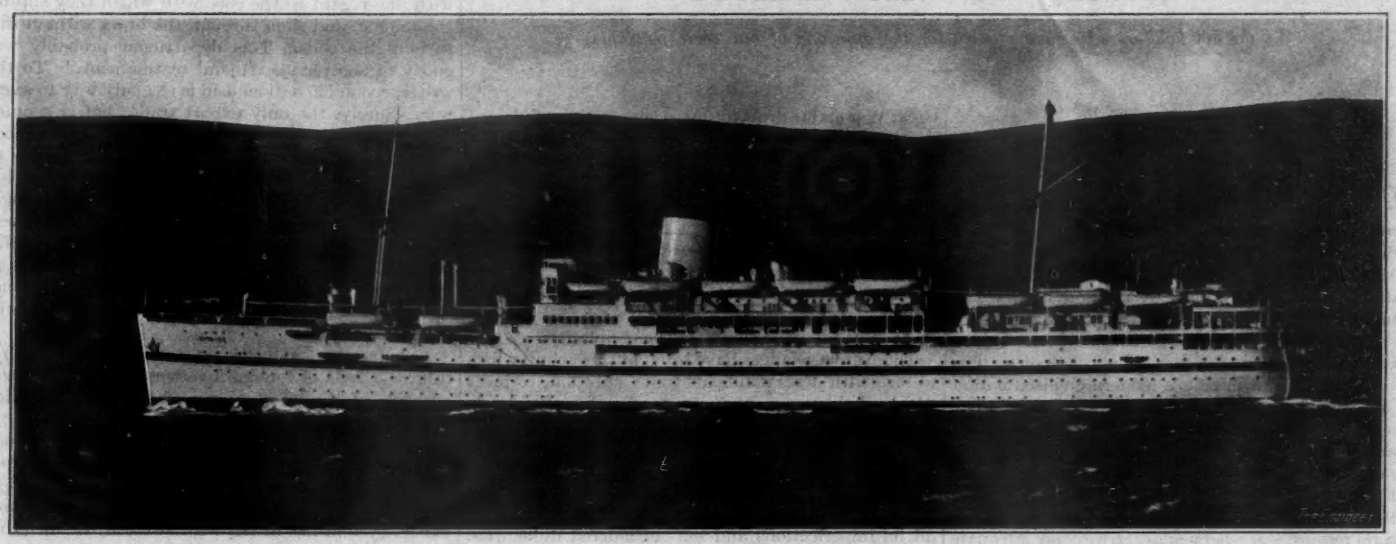
At the end of the year the installation of the main and auxiliary propelling machinery was well forward, and six of the twelve boilers were shipped and placed into position in the boiler-rooms. We show in accompanying engravings the pressure parts of one of the boilers being shipped, ready for lowering into the boiler-room and one of the main condensers ready for shipping. With regard to the auxiliary plant, all four of the main generators are in position, as is also the air-conditioning plant. The whole of the propeller shafting has been placed in position on board. The boilers were built by John Brown and Co., Ltd., at Clydebank, to designs supplied by Yarrow and Co., Ltd., of Scotstoun. The condensers embody the latest features of the Weir closed-feed circuit principle.

The New Holland-America Liner

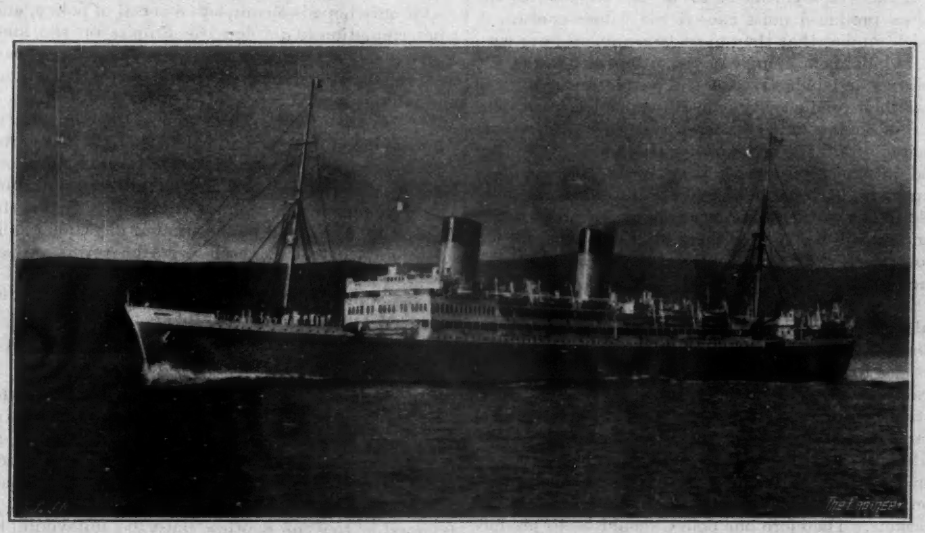
In one of our Supplements we show a view of the new Holland-America liner "Nieuw Amsterdam," which was designed for Atlantic service, and may be looked upon as one of the leading liners of the year. She is the largest ship yet constructed in the Netherlands, and was laid down in the yard of the Rotterdam Dry Dock Company. Some of the shipbuilding and engineering work was entrusted to the firm of P. Smit, jun., of Rotterdam, while the propelling machinery was built by the Royal De Schelde Company, of Flushing. The "Nieuw Amsterdam" was completed in the early part of the year and sailed from Rotterdam on her maiden voyage to New York on Tuesday, May 10th. The principal particulars are as follows:—Length overall, 758ft. 6in.; breadth moulded, 88ft.; depth to main deck, 55ft.; loaded draught, 31ft. 6¾in.; and gross tonnage, 36,287. The liner has seven decks and the passenger accommodation is arranged on the seven upper decks, accommoda-

tion being provided for 568 first-class, 455 tourist, and 209 third-class passengers, which, with a ship's crew of 650, including officers, gives a ship's complement of 1882 persons. The service speed of the "Nieuw Amsterdam" is 20½ knots. The furnishing and decoration of the ship is of a very high standard and embodies some fine Dutch art work. A point of interest about the machinery was the important part played by British contractors in supplying designs and furnishing certain parts of the plant and the navigation and safety equipment.

The turbines, which are of the Schelde-Parsons type, are of special interest, as they embody a combined arrangement of single and double-reduction gears. The first H.P. turbine has a rated output of 3450 S.H.P. at 3600 r.p.m.; the second H.P., 5360 S.H.P. at 1600 r.p.m.; the I.P. 2150 S.H.P. at 1600 r.p.m., and the L.P. 6050 S.H.P. at 1250 r.p.m. With the exception of the first H.P. turbine all the turbines drive the propeller through single-reduction gearing, but the first H.P. is geared to the I.P. turbine shaft through single-reduction gearing, giving a double reduction of speed to the propeller shaft. The steam is supplied by six Schelde-Yarrow side-fired water-tube boilers, of the double-flow type, with air heaters of the horizontal pattern. The designed working pressure is 600 lb. per square inch with a final steam temperature of 750 deg. Fah. The Weir closed-feed system with Weir pumps is fitted, and the sewage system is of the Stone Monoflow type.



P. AND O. MOTOR TROOPSHIP "ETTRICK"



UNION CASTLE LINER "WINDSOR CASTLE"

Some Peninsular and Oriental Liners

On Friday, March 18th, the "Strathallan," the most recent addition to the fleet of the Peninsular and Oriental Steam Navigation Company, Ltd., entered the express service of the company to India and the Far East. Like the previous four "Strath" liners she was designed and built by Vickers-Armstrongs, Ltd., at Barrow-in-Furness. A recent view of the liner is given herewith. The "Strathallan" has a length of 664ft. overall, and a breadth of 84ft., with a gross tonnage of 20,000, and is propelled by a twin-screw arrangement of Parsons single-reduction geared turbines taking steam from six Babcock and Wilcox boilers with a designed safety valve blow-off pressure of 450 lb. per square inch, and a final steam temperature of 725 deg. Fah. Accommodation for 448 first class and 538 tourist class passengers is provided. We illustrate the propelling machinery, as it appeared when erected in the builders' engine shops. Each of the two turbine units comprises one high-pressure, one intermediate pressure, and one low-pressure turbine working in series and driving separate pinions engaging with the main gear wheel. Three B.T.H. turbine-driven generator sets, each of 500 kW to 550 kW capacity at 220 volts, are provided. A more detailed account of the machinery will be found in connection with our description of the "Stratheden," which was published in our issue of December 24th, 1937.

The largest liner of the year to be finished on the Clyde was the P. & O. liner "Canton," which was built and engined by Alexander Stephen and Sons, Ltd., of Linthouse, Glasgow. A full description of the ship, which is illustrated in to-day's Supplement, will be found in our issue of October 14th, 1938. She has a length overall of 562ft. with a moulded breadth of 73ft., and a depth to D deck of 46ft. Her loaded draught is 29ft. 6in., and her measurement 15,784 gross tons. She is designed to carry 260 first saloon passengers, 220 second saloon passengers, and 370 officers, engineers, and crew, making a total ship's complement of 850 persons. The turbine machinery is of the single-reduction pattern, having a designed output of 18,500 S.H.P. at 125 r.p.m. The boilers are four in number and are of the latest Stephen-Yarrow type with five drums and horizontal air heaters. The steam conditions are working pressure 425 lb., and final steam temperature 725 deg. Fah.

Shortly before the close of the year the P. & O. Company took delivery of the new twin-screw motor troopship "Ettrick," a view of which is reproduced herewith. The ship, which was built and engined by Barclay Curle and Co., Ltd., of Glasgow, is specially designed and fitted for the conveyance of troops, and is in many respects generally similar to the British India liners "Dilwara" and "Dunera." Her overall length is 520ft. with a breadth moulded of 63ft., and a depth to shelter deck of 43ft. 4in. Her gross tonnage is 11,279, and she is propelled by twin-screw Barclay-Curle-Doxford, five-cylinder, opposed-piston engines, with a bore of 560 mm. and a combined stroke of 1680 mm. The engines have a total output of 6000 S.H.P. at 120 r.p.m., giving a designed service speed of 14½ knots, which figure was exceeded at the recent successful trials. Excellent accommodation has been provided for 104 first class and 90 second class passengers, and for 164 troop families and 1164 troops. A feature of the design is that while the "Ettrick" has been primarily built as a troop-carrying ship, she can be readily converted for the owner's normal passenger and cargo service. Whilst engaged in carrying troops permanent ballast in the form of road metal is carried in Nos. 2, 3, 4, 5, 6, and 7 holds in order to ensure suitable immersion and trim.

In the course of the year an official statement was made by Lord Craigmyle and Sir Edward Beatty on behalf of P. & O. and C.P.R. interests with regard to the building of the two large liners designed by Mr. John Johnson for Pacific-Australian service. Although an agreement has been reached by the Governments concerned, the price of the ships is regarded as too high and the placing of the orders has therefore been postponed for the time being. The hope may be expressed that this matter may soon be reconsidered and the orders placed at no distant date, as the liners are urgently needed to maintain British shipping interests in the Pacific Ocean.

The Union Castle Liner Programme

Two of the outstanding motor liners of the year were the Union Castle Line's new ships "Capetown Castle" and "Durban Castle." A sister ship, the "Pretoria Castle," is now fitting out at her builders' yard, the Belfast establishment of Harland and Wolff, Ltd., along with two fast fruit-carrying ships, the "Richmond" and "Rowallen" Castles. The completion of these ships will mark the end of one of the largest contracts of recent years for new construction, and the re-engining of five ships, in order to reduce the time taken for the mail service to South Africa from 16½ to 13½ days. The "Capetown Castle" is illustrated in to-day's Supplement. She has a length of 734ft. 3in. overall, with a beam of 82ft., and a gross tonnage of 27,000. She is designed to carry 292 first class and 499 second class passengers. Her service speed is about 19 knots, and her propelling machinery consists of twin-screw, two-stroke, double-acting Harland-B. & W. oil engines with a service output of 24,000 S.H.P. total. The engines are ten-cylinder units with a bore of 660 mm. and a stroke of 1500 mm. There are five Harland generating sets, each with an output of 700 kW, and a 50-kW

emergency generating set, and a reserve battery are also carried.

During the year the "Windsor Castle" has been lengthened and new machinery comprising twin-screw Parsons geared turbines of about 20,000 S.H.P., taking steam from the latest design of two-drum Babcock-Johnson boilers with a working pressure of 425 lb. and 750 deg. Fah. final temperature, has been installed. A view of the ship as she now appears with her two funnels is given in an accompanying engraving, and further illustrations of the turbines and boilers for her sister ship, "Arundel Castle," will be found in our issue of January 14th, 1938. Further re-engining included the installation of new two-stroke machinery instead of the original four-stroke, double-acting engines in the motorships "Carnarvon Castle," "Warwick Castle," and "Winchester Castle," the last of which is now in hand.

(To be continued)

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

WHY FOREIGN TRADE?

SIR,—The letter from "M.I. Mech. E.," which appeared in your issue of December 16th, is most opportune, and will render a useful service if it excites thought and discussion on the subject of our foreign trade.

At the present juncture of world affairs it is more than ever necessary to clear away some of the misconceptions which have become the popular currency of thought on this vitally important subject.

There are two main fallacies at opposite poles. The one is that it is possible for a modern civilised nation to live in a state of isolated self-sufficiency. The other that there is some inherent quality in international trade which inevitably makes it profitable to engage in it.

The idea of self-sufficiency of a single sovereign State is self-condemned because it assumes that the natural resources of a particular territory are adequate and varied enough to provide means of satisfying the highly artificial and complex requirements of modern civilised life, whereas such conditions are unknown. The alternatives, therefore, are either to confine the life of the people within the limits of the natural resources, which is impossible, or to replace natural by synthetic products, which would be equally impossible to the full extent and variety of the requirements, apart from the fact that it would be an abominable perversion of life.

The idea that foreign trade possesses some inherent magical quality whereby through circuitous processes merchandise of a given value, *i.e.*, a given weight of fine gold, can be exchanged into a greater weight of fine gold is, of course, equally fallacious. The idea no doubt is a relic of the so-called good old days when the more advanced and sophisticated peoples were able to exploit the ignorance of the more primitive peoples in driving a bargain.

The advantages of foreign trade are not absolute, but relative and, above all, conditional. A foreign trade transaction may be profitable or unprofitable to either or both the importer and the exporter, and it may be profitable or unprofitable to one or both of the countries concerned, regardless of whether it is profitable or unprofitable to either or both of the actual parties to the transaction. In some cases, the only net gains may be those of the banker, the shipowner, and the insurers.

A fundamental fact is that, apart from the yield of wealth accumulated in the past, a nation's only means of livelihood are the fruits of the quality and quantity of the mental and bodily activities of its people applied to the material resources at their command. International trade certainly does not provide an escape from this condition of existence by affording opportunities of getting something for nothing. But it does effect international exchanges of something of one kind for something of another kind, whereby the deficiency of one country is filled from the sufficiency of another country, with the result that the activities of the people can be better sustained and more fully developed, whilst the amenities of life are enhanced by the enjoyment of things otherwise unobtainable.

Regarded from a wider point of view, the benefits of international trade to the human race derive from the fact that, by distributing and imparting a market value to the products, it makes economically possible the exploitation of the natural resources of the different parts of the world. In other words, international trade increases the world production of new wealth and distributes it amongst the peoples of the world.

Until about thirty years ago the mutually complementary basis of foreign trade whereby we exchanged manufactured goods for primary products worked well from our selfish point of view. Then came the Great War and the revolutionary changes that followed in its wake, the sense of insecurity bred from which excited an almost worldwide desire for greater security through increased independence, and from this sprang economic nationalism and the determination of the primary product exporting countries to establish secondary industries partly with the object of becoming less dependent on foreign manufactures and partly for the purpose of providing more congenial and progressive vocations for the younger and better educated classes of the population.

These great changes have brought this country face to face with a very difficult trade situation, to meet which bold new thought and vigorous trade reorganisation will be necessary.

As it will scarcely be denied that overseas trade is essential to the life of this country, the practical question arising is how to conduct it to our best advantage in the world of trade as it is to-day, with all its imperfections and self-engendered difficulties.

Whatever may have been the case in bygone days, it has been forcibly brought home to us in recent times that, in some considerable measure, our overseas trade must be planned and controlled. Without a tariff, this would have been impossible, and unless the Government exercises powers to check dumping, impose quotas, restrict exemptions from import duty, and insists on greater reciprocity in trade, it will be impracticable to make control sufficiently effective.

The first requirement is that the planning and control should be so directed as to ensure the adequate and suitable employment of our own people, there being no ethically and economically sound substitute for such employment.

If the employment is to be self-supporting the values produced must exceed the values consumed, which implies that they must be commensurate with the standards of living enjoyed. In other words, the abilities and industries of the people must be such that their productivity is in correspondence with the ease of circumstance required by them in reward for their efforts. The necessity for this balance of output and intake applies with very special force to our export trade, because our goods and services can be sold in the overseas markets only at the prices which can and will be paid for them by people who, for the most part, lead harder lives and command less purchasing power.

So far as manufactures are concerned the required balancing value of goods produced for export may range from larger quantities of inferior low-priced articles to smaller quantities of superior and higher-priced articles. But the social and economic conditions in this country, and the long-established traditions and practice of our highly developed industries, which have earned a worldwide reputation for good quality, make it extremely difficult for us to compete with some other countries in the lower-price markets. Therefore our policy should be to produce and export the largest possible proportion of high-class products in which we can hold our own.

To enable us to offer these goods at saleable prices our manufacturers must have the benefit of the largest possible share of the home market so that the volume of output may be such as to permit of economic production.

I therefore entirely agree with "M.I. Mech. E." that we cannot afford to import in any considerable quantities the very kinds of high-class manufactures on which we will have to rely for our indispensable export trade.

We must put an end to the folly of exchanging, for example, machinery for machinery, instruments for instruments, textiles for textiles, &c. &c.

D. A. BREMNER,
Director, British Engineers' Association.
32, Victoria Street, London, S.W.1,
January 2nd.

SIR,—The letter from "M.I. Mech. E.," in your issue of December 16th is very much to the point, and demands attention.

Ours is a logical profession, and your correspondent's remarks regarding the nonsense of the claim that international trading is an instrument for peace will be accepted without the proof recently given by Mr. Hudson in Parliament. I refer to his remarks regarding unfair trading, and in particular those dealing with the wickedness of our countries giving more than world prices for commodities.

The same people who assert that our prosperity depends on our export trade are equally dogmatic regarding the evils of what is termed "economic nationalism." I fancy that these people keep a highly paid "Catch Phrase Dept.," coining terms with due regard to the ease with which they slip off the tongue, and slide through the brain without disturbing the cells. This department probably was guilty of the phrase "moral rearmament." To the writer, economic nationalism is the only way to avert war. Surely, the only export trade that is genuine is the exchange of goods which we require for goods that someone else needs, either by direct barter or by "roundabout barter," *i.e.*, through third parties.

But the most serious matter, in view of the strongly entrenched position of the existing financial system, is the effect of our foreign investments on home affairs. If the title to existence is to consist as at present in the possession of a job, then the sooner these investments vanish the better for those who need work.

The farming industry is the principal sufferer from the evils of foreign investments. For a recent example of the effect of a loan made to a foreign country, which, until it is defaulted on, will be a continuous loss to the people of this country, we may turn to the bridge built for Denmark, out of the proceeds of a loan floated in this country.

It seems to the writer that the only hope of a sane export system lies in the realisation of the fact that nothing is so important as a happy and contented people. That will only be brought about by a revival of our farming industry, and that, in turn, demands a restriction of our exports to balance imports, the latter reduced to sheer necessities.

One might go further and comment on the futilities of the export trade in coal, whereby we sell a "wasting asset," in the raw state at cut prices, and at the same time lose the home trade in the commodity by trying to recoup the losses on the export trade by charging uneconomic prices to home consumers.

Surely it is time we gave up peevishly asking why other nations start becoming industrialised, and no longer remain content to produce primary commodities and take their chance at world prices.

Our only hope is a complete reversal of policy, and a determination to develop the Empire on the lines at present being carried out by New Zealand. That, in turn, demands that we should rate the comfort and happiness of the people as of far greater importance than the wealth of a section of the community, who, as your correspondent "M.I. Mech. E." suggests, would be employed just as usefully, and far more healthily, in digging holes and filling them up again.

"Si monumentum requires circumspice" runs the epitaph to Wren, and in the stunted physique of the inhabitants of the Lancashire cotton towns we see the price paid for the export cotton trade.

"It is a mad world, my masters." The question is, however, Is the insanity curable?

December 24th. KYRLE WILLANS.

SIR,—I wonder whether one of your readers, who is a mathematician rather than an economist, will oblige me by stating whether it is possible for *all* nations simultaneously to have a favourable trade balance, or whether it is inevitable that if the trade balance of one nation, or one group of nations, is favourable that of another must be unfavourable. It seems to me that on the answer to this question a very great deal depends. If all nations can simultaneously have a favourable trade balance, then, so far as trade is concerned, the nations of the world can live at peace with one another. If, however, it is inevitable that a favourable trade balance in one quarter must be accompanied by an unfavourable balance in another, then must international trade contain within it the seeds of possible armed conflict. C. T. A.

London, December 30th.

SIR,—Your correspondent, Mr. Robin Vincent, appears to state his case well and is to be congratulated.

It will be agreed that the fiscal and financial policy of our country should be devoted to its prosperity, but the fact that we are the most heavily

taxed nation in the world suggests that something is wrong.

In addition to taxation we have some 2,000,000 unemployed in a population of 45,000,000.

I think Mr. Vincent invites us to infer that:

(1) The country is not utilising its financial policy to the full, but rather that financial interests are exploiting the country;

(2) Our fiscal system needs overhaul.

If we look at (1) we find we have at the present time the largest adverse trade balance in our history. If the adverse balance were in raw materials no great objection could be taken, for that would be prosperity indeed. Moreover, if British shipping was benefiting to the full from these imports, the need for a subsidy would not be so imperative. If the purchase of foreign goods is essential to pay interest on foreign loans and capital abroad, a remedy is demanded at once.

Is it that the preservation of capital invested abroad is much more important than prosperity at home? There may be some abstruse principle of economics involved which either Mr. Vincent or some of your readers can elucidate.

As regards (2), it will be interesting to know what is preventing the extension of the import duties rather than the use of quotas.

The motor industry was made by these duties, and what has been done once can be done again. An emergency armaments tariff of 10–15 per cent. on imports would yield a handsome amount and relieve taxation when relief is urgent.

After all, who will venture new schemes when taxation is at its present level and there is no security from foreign dumping? We cannot trade or exist within ourselves, but we can insist on a closer approximation between imports from and exports to those countries with which we trade. In no case of any magnitude are we in the more favourable position.

The opinion of your readers will be appreciated.

W. HALL HICKIN.

London, December 30th.

FUEL FOR ROAD VEHICLES

SIR,—In defence of an old friend, the gas producer, may I be permitted to challenge a few of the implications conveyed by your leading article of December 23rd?

Thirty years ago and more there were at work in this country a large number of gas producer power plants varying for the most part from 10 to 200 H.P. and giving reliable and highly economic service often in the hands of unskilled labour. I recall the stock advertisement of one well-known maker of such plant which for years claimed to provide 10 B.H.P. hours at the cost of 1d. at the then current price of suitable fuels.

Sir Frederick Bramwell's prophecy did not, unfortunately, take into account the advent of Diesel power and oil fuel, which, offering, as it did, a self-contained plant with the immense jump of some 15 per cent. in net thermal efficiency at one bound, as well as avoiding the work of cleaning scrubbers and the labour about the producer, light as it was, inevitably resulted in supplanting the gas producer so long as oil was freely obtainable at a reasonable price. There lies the rub to-day with the quite probable result that this prophecy will yet see complete fulfilment.

With a world situation threatening oil supply and, in event of war, certain to enhance its already high price, and with improvements in producers themselves, the position to-day is favouring a revival of this class of power plant as never before.

So far as small portable producers, and especially for road transport, are concerned, surely the fact that there are 6000 gas-operated vehicles in France, 1500 in Italy, and 1207 in Germany to our total of some dozen in England, tends rather to prove that the fault lies in our proverbial slowness in the "uptake" than in any serious defect in the system, for the engineering qualifications of our Continental neighbours are not in question.

Maybe our confidence in maintaining oil supplies has for many reasons been greater than theirs; maybe we are as a nation less inclined to put up with the inconvenience of the little manual labour which handling solid fuel as against liquid fuel implies. But it is dangerous in uncertain times to defer precautionary measures too long; in the field of rearmament we have seen that already.

As regards your contention that the steam wagon may still offer the best solution for heavy transport, this development was essentially a British production, and it is instructive to note that one of the most successful manufacturers of steam wagons and small geared locomotives has but recently sponsored the exploitation of a gas producer vehicle with every possible opportunity of testing the rival merits of the two systems!

The producer is by no means the first invention to emerge, enjoy a short period of prosperity, and have its future nipped in the bud by some temporary change in general conditions, only to arise Phœnix-like from its own ashes when those conditions pass. The Serpollet flashboiler is such an example, for it is certainly the parent of some of our latest advances in high-pressure steam generators.

One does not forget the possibilities of the solid-fuel Diesel engine, but taking the question of wear, the preparation of the fuel and its storage in fit condition for introduction to the combustion chamber, it is quite possible that when all its present problems are overcome it will offer no commercial economy over gas power in its modern application. We have also yet to learn the possibility of the latter when enriched with hydrogen under the Erren patents which are now reported to be under development by a well-known firm of gas engine manufacturers.

The whole question is what do we seek—economy in B.Th.U's or economy in L.S.D.? The technical mind is influenced by a gain in thermal efficiency often at the cost of simplicity and first expense, the ultimate effect of which on the balance sheet shows no gain to the shareholder or owner of the plant. Fuel is not the sole expense by any means, and the true answer to this question must lie, as usual, in a happy compromise. Add to this the present position of oil fuel, and it can fairly be claimed that the revival of gas power and the gas producer offers to this country a way out which our Continental rivals have been quicker to see, and which we shall do well to follow. I do not think its past performance, even in its early days, justifies the doubts expressed in the latter part of your article to those of us at least old enough to remember its satisfactory service in the coal power era to which circumstances are forcing us to return.

Southsea, Hants, December 27th. S. P. CHRISTIE.

SIR,—In your article "Fuel for Road Vehicles" in your issue of December 23rd, you refer to a proposal which the Transport Producer-Gas Plant Makers' Association has made to the Government in regard to the use of portable gas producers. This proposal is not that the Government should create a stock of producers which would be hired to operators in an emergency, but that from this stock units should be hired now. Apart from prejudice, lack of fuel distribution and discriminatory taxation, the principal obstacles to increased utilisation here are the relatively high cost of conversion and the reluctance of many operators to pay down capital in order to save over a period. By the proposal suggested, these latter difficulties at least would be overcome while affording a security against war, and in the meantime giving employment to miners and others and reducing the unfavourable balance of trade.

May I also agree with your final paragraph in regard to the importance of improving the methods of using solid fuel in vehicles? In the paper before the Institute of Fuel by Mr. Clarke Jones and myself (to which you refer elsewhere in the same issue) we have made specific reference to this: "The requisite technical knowledge exists in this country for the development work to be completed, but suitable facilities are lacking to those who possess the knowledge." I believe that this situation may shortly be rectified in view of the new attention being paid to the subject by many who have hitherto neglected it.

KOELA PRODUCER-GAS PLANT COMPANY, LTD.,
BOSWORTH GOLDMAN.

London, W.C.2, December 30th.

NON-DESTRUCTIVE TESTING—THE POWDER METHOD

SIR,—The testing of ferro-magnetic materials by the "powder" method has become deservedly popular in this country during the past few years. The various excellent sets of apparatus which are now marketed for this purpose will unquestionably stimulate its use in an even wider and more general field.

In some cases of specialised application the test has been alleged to fail. This has been due to a lack of appreciation on the part of the user of the broad principles involved. Consequently, the apparatus was improperly used and inexperience in interpretation led to a premature condemnation of the process. It appears necessary, from the writer's experience, therefore, to inculcate one or two elementary principles if reliable results are to be generally obtained, and the process is not to suffer discredit.

There are several important, howbeit simple, points which should be borne in mind when the non-expert prospective user is considering the application of this test in a particular case.

(1) The method, when used under ordinary conditions, will only detect surface and immediately sub-surface flaws.

(2) Flaws show best when they are at right angles to the magnetic field; thus, longitudinal magnetism will show transverse flaws, and annular magnetism will show longitudinal flaws.

It is now possible to obtain apparatus commercially which is so arranged that both types of magnetic field may be obtained without moving the specimen.

(3) It is possible to effect magnetisation of a specimen by placing it in a continuous magnetic field, *e.g.*, between the poles of an electro-magnet. On the other hand, magnetisation may be effected by passing a heavy current, for a very short time, either through the specimen itself, or through a conductor wound round it. This method, for example, may be used when it is desirable to show a transverse flaw in an object such as a tube or similar article.

In the second case, the specimen is sprayed with the magnetic ink after the magnetising influence is removed, and the concentration of the iron depends upon the remanent magnetism in the specimen. The efficiency of this method obviously depends upon the material of the specimen. Mild steel has a very low magnetic remanence and therefore would be a bad subject for this type of test. On the other hand, some of the high alloy steels would be eminently suitable for it.

(4) There is an optimum magnetic flux density to produce the best result. If the magnetic field is too strong, it may result in fortuitous patches of iron concentration which may be wrongly interpreted to indicate flaws.

(5) Cold work, stress concentration, &c., will produce local variations in magnetic permeability and thus lead to patches of iron concentration. The appearance of such patches is usually characteristic, but the phenomenon may easily be misinterpreted.

(6) Difficulty has occasionally been experienced in detecting iron concentration when the surface of the specimen is rough or blackened. This may be overcome by the application, before magnetisation, of a thin coating of quick-drying white paint.

(7) Permanent records may be made of flawed areas, shown up by the iron filings, by the simple method of first coating the surface of the specimen with cellulose acetate varnish, which easily strips off when dry. A volatile solvent is added to the iron suspension before it is applied. The solvent attacks the varnish and allows the iron to be sprayed into it and so form a permanent pattern.

Interpretation of ferrographic results is largely a matter of experience; but it may be said that the indications obtained by a proper use of this method are reliable and comprehensive.

Ferrographic testing endows the engineer with a quick, non-destructive testing operation for special cases, which combines perfect efficiency and reliability, within its limits, with low capital cost and insignificant running expense.

December 28th. V. E. PULLIN.

New Headquarters of the Institution of Heating and Ventilating Engineers

THE new headquarters and offices of the Association of Heating, Ventilating, and Domestic Engineering Employers and of the Institution of Heating and Ventilating Engineers, at 22, Russell Square, London, W.C.1, comprise a four-storey building in which the basement is used for storage purposes, cloak room and lavatories; the ground floor for offices; the first floor for the Council Chamber and library; the second floor for a meeting room and committee room; and the third floor for the caretaker's flat. The design of the heating, ventilating, and hot water supply systems was governed partly by the fact that it was not desirable to cut existing brickwork or to disturb existing floors, and partly by the comparative shortness of the lease on which the building has been taken.

The heating system is a low-pressure hot water apparatus served by a gas-fired boiler. Circulation is maintained by gravity and standard pattern cast iron radiators have been used, except on the first floor where concealed convector type heaters have been used. To ensure satisfactory operation of both types of heaters under all conditions of load and to make provision for the effect of winter sunshine on the heat requirements of those rooms with a south aspect, two independent circuits have been provided. One

circuit serves the radiators in the rooms on the south side of the building, and the convector heaters in the Council Chamber and library. The other circuit serves the radiators in the hall and in the rooms on the north side of the building.

The temperature control of the apparatus is operated electrically. The boiler is maintained at a constant temperature by means of limit thermostats, the usual day temperature setting being 180 deg. Fah., the night setting being considerably lower. An electrically wound clock switch changes the control of the boiler from the "day" to the "night" thermostat, and *vice versâ*. Flame failure protection of the gas boiler is provided by the installation of a thermostatic device which would shut off the main gas burner and also the by-pass flame. The circuit which serves the radiators on the south side of the building and the convector heaters on the first floor is maintained at a constant temperature, and is connected directly to the boiler headers. Each room served by this circuit is provided with individual temperature control, consisting of room thermostats and magnetic valves which govern the supply of hot water to the radiators and heaters. The circuit which serves the radiators in the hall and the north of the building is fitted with a recirculating by-pass and a motor-driven valve which is operated by an automatic temperature controller. The temperature in this circuit is therefore automatically controlled to give approximately constant room temperatures, regardless of variations in the weather.

Mechanical ventilation has been provided for the Council Chamber and the meeting room. In both cases an electrically driven centrifugal extracting fan has been provided in the roof space, and is connected to the rooms by ducts. Fresh air inlets are provided behind concealed convector heaters fixed below the windows. Each fan is provided with remote push-button control, and can be operated from stations on the landings outside each of the rooms and from similar stations in the roof space. The fans can be run at two different speeds, a high speed for summer use and a slow speed for winter use. Either speed can be selected from the push-button station. The Council Chamber fan is capable of maintaining a rate of ventilation of three changes per hour for winter use and six changes per hour for summer, and the meeting room fan gives four changes per hour for winter and eight changes per hour for summer.

No central apparatus has been provided for the hot water supply points in the building, as these points are few and rather scattered. In each case non-storage type gas water heaters have been provided. The outlet from each heater has been connected to the hot water tap on the fitting to be served. Each heater comes into operation when the hot tap is opened.

The building has been rewired throughout for lighting. To avoid cutting the existing wood joists, the system is partly in lead-covered cable and partly in screwed steel conduit. Partly on the ground of economy and partly to avoid any unnecessary cutting away of old plaster, there has been no attempt to exploit "architectural lighting." The lighting positions generally have been decided to maintain an equal balance between ease of wiring and good effect, with good distribution of light as the necessary condition. In the Council Chamber and in the library the fittings are of the recessed louvre type, consisting of multiple parabolic reflectors enclosed in metal boxes recessed into the walls at a height of about 8ft. 6in. above the floor, the front of the boxes being finished with slotted wooden mouldings holding champagne coloured glass louvres sloping upwards. The fitting in the committee room on the second floor is also of a special type. The remainder of the fittings are of the spherical pattern, the sizes having been chosen to allow the insertion of the next larger size of lamp in each case, should general standards of illumination rise in the future, as they have in the recent past.

Sundry manufacturers gave nearly all the materials which were required for the heating, ventilating, and hot water supply systems, and the installation work was carried out and donated by a group of member firms of the Association.

Personnel Changes in the P. & O.

THE Peninsular and Oriental Steam Navigation Company announced the retirement at the end of last year of Mr. Robert T. Clarke, who since 1926 has been superintendent engineer of the company, and has seen during the years of his office the construction and commissioning of the modern P. & O. fleet. Mr. Clarke was born in 1866 at Twickenham and received his education at Pitsmoor College, Sheffield. In 1882 he was apprenticed in the drawing-office of John Brown and Co., Ltd., of Sheffield, and afterwards spent some time in the shops and on outside erection work. He joined the P. & O. Company in 1889 and spent twenty-three years of service at sea. In 1912 he was appointed superintendent engineer at Bombay, and in 1919 was entrusted with the supervision of the machinery of the new ships which at that time were being constructed by the P. & O. Company under its large post-war shipbuilding programme. In 1926 Mr. Clarke was appointed superintendent engineer to the company, a position which he has continued to hold with distinction and esteem. In the period of twelve years, during which he has been responsible for the machinery of the new ships, some notable advances in construction have taken place. With the introduction of the turbo-electric drive the "Viceroy of India" was completed by Alexander Stephen and Sons, Ltd., and the British Thomson-Houston Company, and similar machinery was adopted for the Armstrongs-Vickers built ships "Strathaird" and "Strathnaver," later the "Strathmore," "Strathaeden," and "Strathallan" were all completed at Barrow-in-Furness, and there followed the Stephen built ships, the "Corfu," "Carthage," and "Canton." In all these later ships single-reduction geared turbines taking steam from high-pressure water-tube boilers was adopted. The last liner to be commissioned during Mr. Clarke's term of office was the troopship "Ettrick," which was built by Barclay, Curle and Co., Ltd., and equipped with Barclay-Curle-Doxford opposed-piston oil engines. The ship is illustrated elsewhere in our pages. We join with Mr. Clarke's many personal friends and colleagues in wishing him long life and happiness in his retirement.

Consequent on the retirement of Mr. R. T. Clarke, referred to above, the P. & O. Company has appointed Mr. David Goodsir and Mr. Sydney A. Smith, M.Sc. (Eng.), M.I. Mech. E., M.I.N.A., as its superintendent engineers. Mr. Goodsir will be in charge of maintenance and personnel, and Mr. Smith will be responsible for new construction. Mr. David Goodsir was born at Kirkcaldy and served his apprenticeship with W. M. Melville, engineers of that town. He entered the P. & O. service in 1905 and after serving nine years at sea was appointed head of the engineering department of the company's dockyard at Bombay. He served in that capacity until 1919, when he went to sea again, later being appointed chief engineer of the s.s. "Mooltan." Mr. Goodsir also served as chief engineer of the "Viceroy of India" and "Strathaird." In 1934 he became resident chief engineer at the naval construction works of Vickers-Armstrongs at Barrow for the building of the "Strathmore" and returned to Barrow in 1936 for the construction of the "Stratheden" and "Strathallan." In 1937 he was appointed assistant superintendent engineer in London.

Mr. S. A. Smith has been associated with the P. & O. Company for twenty-eight years and during the past twelve years has been in charge of the engineering technical department. He obtained the London University Degree of B.Sc. (Engineering) with first-class honours in 1924, and the M.Sc. (Eng.) degree in 1927 for a thesis on the "Balancing of Engines and Vibration of Ships having Twin-screw Machinery." He is a member of the Institution of Mechanical Engineers, a member of the Institution of Naval Architects, and a member of the Council of the Institute of Marine Engineers.

SIXTY YEARS AGO

The Progress of Engineering in 1878.—A large part of our issue of January 3rd, 1879, was devoted, in accordance with our custom, to a review of the progress of engineering during the preceding twelve months. We had to record continued depression in almost every branch of manufacturing and constructive industry. Cheapened labour, we said, had effected little and increased facilities for cheapening production had failed to attract custom in our staple industries. Almost the only country in the world which was not in the same condition was France, where ambitious public works schemes were in progress or were projected under the bold programme of Monsieur C. de Freycinet, the Minister of Public Works. Under that programme, most of which had already been sanctioned, about 5500 miles of new railway were to be built, £30 million were to be spent on canals, and about £10 million were to be devoted to the improvement of ports and harbours. We recorded the completion and opening of Bouch's Tay Bridge and the Maria-Pia bridge across the Douro, designed and built by Eiffel and Co., of Paris. The foundations for the shore piers of a long bridge across the river Forth had been laid. [This bridge was to have been constructed to the designs of Mr. T. Bouch, but when, a year later, the Tay Bridge collapsed, work upon it was abandoned, the great cantilever structure which we now know as the Forth Bridge taking its place.] The Severn railway bridge had been completed except for two spans, and work on the Severn tunnel was progressing in spite of the great engineering difficulties that had been encountered. Financial as well as engineering difficulties had attended the construction of the St. Gothard tunnel. Although its length was only 9½ miles, six years had elapsed since it was begun, and it was estimated that it would not be completed until 1896 (*sic.*). [The tunnel was in fact opened in 1882.] The Manchester and Liverpool ship canal scheme was in abeyance, awaiting the advent of better times. It was influentially supported, but, we remarked, to execute Mr. Hamilton Fulton's plans would involve an expenditure of about £3½ million. Progress in mechanical science had, we maintained, got into a groove so far as the steam engine was concerned. The hot air engine was not developing as rapidly as was at one time anticipated, nor was the Brayton engine—which we described as a link between the hot air and the gas engine—being extensively applied. The true gas engine had, we said, made enormous strides since the Lenoir engine was introduced for supplying power in hairdressers' shops, but there was still room for improvement in it. We dealt at some length with developments in the iron and steel industry and mentioned incidentally the process of refining Cleveland pig iron, which was being tried by Stevenson, Jaques and Co. at Middlesbrough. This process, we said, was known as Smyth, Thomas and Gilchrist's patent. It consisted of blowing air at about 3½ lb. pressure and charged with petroleum through molten pig iron contained in a large tank. The tank was lined with a plaster composed of magnesium limestone and purple ore, which melted during the blow and had a refining action on the impurities. A charge consisted of about 5 tons, and after a blow of half-an-hour all the silicon and four-fifths of the phosphorus were said to be eliminated. The petroleum vapour in the blast was stated to give a complete command of the temperature and to facilitate the retention of the carbon and consequently to promote the fusibility of the product. In naval construction we described the decision to clothe the new turret ship "Conqueror" wholly in steel as an apparent victory of steel over iron. From various experiments and considerations, however, we drew the conclusion that the best armour would be found to consist of a thin, hard, brittle steel face attached to a thick wrought iron foundation plate.

WILLIAMSBURG POWER STATION

IN enlarging the Williamsburg steam power station, which supplies 25-cycle current to the Brooklyn underground lines of the New York rapid-transit system, the high cost of land led to a vertical development of the new extension. The plant had seventy-two boilers of 6000 square feet heating surface, generating steam at 200 lb. pressure, and 100 deg. superheat; they served eleven turbo-generators aggregating 182,500 kW. In the new extension are two water-tube boilers, working at 850 lb. and 830 deg. superheat, feeding two superposed turbo-generators of 18,750 kVA each, and exhausting into the existing 200 lb. steam mains. Coal is supplied from barges on an adjacent canal and is stored in overhead 5000-ton steel bunkers which are built into the structural frame of the building. The feed pumps and coal pulverisers are at 8·17ft. above the water line; air coolers, &c., 23·44ft.; generator and boiler-room floors, 38·17ft.; top of coal bunkers, 138·50ft.; roof, 162ft. The boiler-room is about 160ft. high. Each boiler, with a capacity of 575,000 lb. per hour, is of the single-pass type, with economiser and superheater above the steam generating tubes, the flow of gas through these upper sections being controlled automatically by dampers to maintain the steam pressure at 830 lb. for all loads between full and half load. The burners are supplied by automatic feeders from motor-driven double-roll ball pulverising mills. Flue gas from the economiser and superheater sections passes through preheaters and electrostatic ash precipitators, beyond which the gas is delivered by induced draught fans to a radial brick chimney, 13ft. in diameter and 115ft. high above the roof. Two reaction type turbines at 1500 revolutions drive each a generator of 18,750 kVA, three-phase, 25-cycle, 11,000-volt current. The exhaust steam will serve one of the older 35,000-kW turbo-generators. Poor quality of condensing water necessitated high requirements for purity of condensate. A rotary type filter has an automatic back-washing attachment to clear the water supply for the large air and oil coolers. Turbo-driven boiler feed pumps deliver, each, 625,000 lb. per hour of water at 380 deg. Fah., from 225 lb. suction to 1200 lb. discharge pressure.

"THE CONTROL OF DIESEL RAILCARS."—In our report in our issue of November 25th of the discussion on Major Wilson's paper before the Institution of Mechanical Engineers we ascribed to Professor Lomonossoff a remark referring to "the Second World Power Conference held in 1930 in Berlin under the chairmanship of Mr. Chorlton." We believe we reported Professor Lomonossoff's words correctly, but it is desirable to make it clear that the chairman of the Conference was Dr. Köttgen. Mr. Chorlton was Vice-Chairman of Section 31, the chairman of that section being Professor E. Schimanck.

MERCHANT SHIP RESERVE SCHEME.—After a meeting of the Tramp Shipping Section of the Chamber of Shipping it was announced that, after careful consideration, it had been decided to postpone Mr. Philip Haldin's scheme for a reserve of ships until such time as the industry desired to reconsider it. This scheme, which was drawn up by Mr. Haldin, of the Court Line, was for the establishment of a company which would purchase tramp steamers at about breaking-up prices. The vessels would then be laid aside as a reserve available at the Government's call in times of emergency. It was suggested that the company would pay 10 per cent. of the purchase price of any vessel and the balance under the scheme would be advanced by the Government on mortgage, free of interest.

River Control and Water Storage in 1938

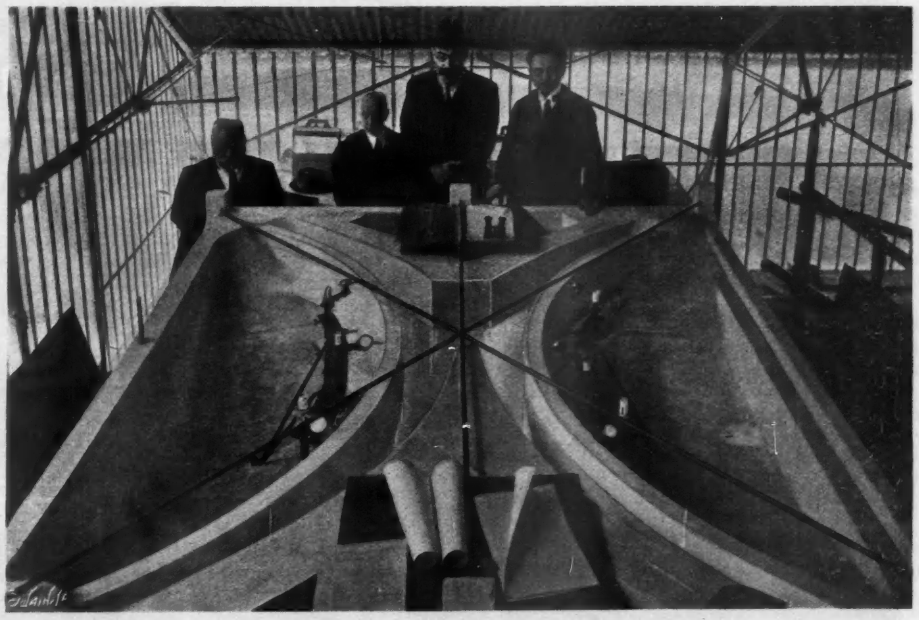
AS far as this country is concerned activity in the construction of dams, barrages, and other large structures for storing or controlling the flow of water was not considerable during 1938. A large amount of work was, however, proceeding in the general improvement of rivers by dredging, widening, cleaning, building up banks, &c., by the various Catchment Boards concerned. The work carried out over the length of the River Nene, described and illustrated in a recent issue, affords an example. It is likely in the near future to restore to Peterborough its ancient status as an inland port, and barges will be able to travel thence at least as far up as Northampton and make connection with the canal system of the Midlands. Many other such schemes, not all of such magnitude, are being executed, but they are not suited for description in such a short review of the year's work as this. Some details will be given in our Tabular Summary of Civil Engineering Contracts to be published a fortnight hence.

The possibility of one great project for a new water power scheme in Scotland seems to have been definitely ruled out by the decision of the House of Commons to refuse its sanction. It will be recalled that in 1937, after the Bill for the Caledonian power scheme had been rejected for the second time by the House of Commons, the Government set up the Calcium Carbide Factory Investigation Committee with the object of reviewing the position and recommending a scheme for the manufacture of carbide in this country. That Committee recommended the scheme put forward by the British Oxygen Company, Ltd., the original promoters of the Caledonian power scheme, for a coal-burning factory at Port Talbot, South Wales, in conjunction with a factory at Corpach, on Loch Linnhe, near Fort William, supplied with current from the Caledonian power development. The water power scheme was worked out for the promoters by C. S. Meik and Halcrow, of Westminster. Despite this recommendation and despite the fact that substantial agreement on a number of questions previously at issue had been reached, leading to the deletion of a clause in the Bill relative to the compulsory acquisition of land, which had aroused some criticism, the Bill was, in March, decisively rejected for the third time by Parliament. Nothing further has since been done and the idea of erecting a factory in Wales seems also to have been dropped.

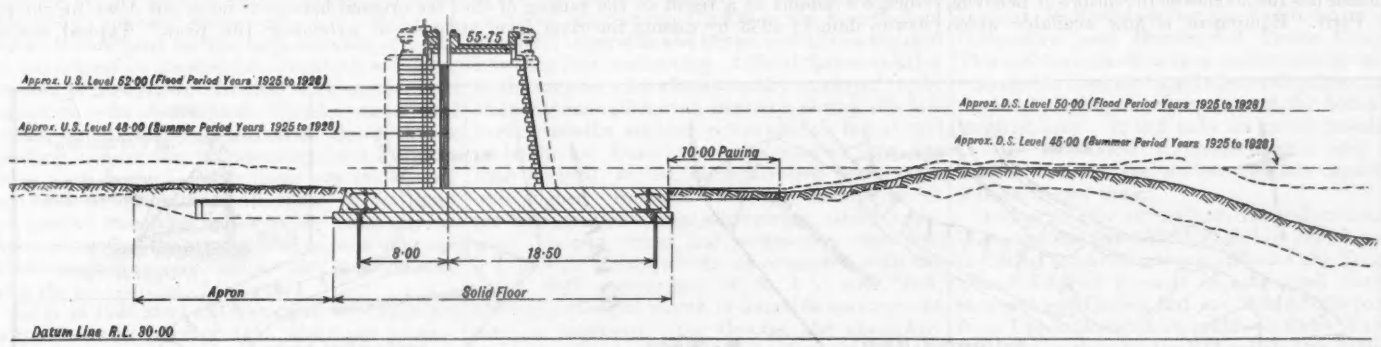
On the Lochaber power scheme serving the works of the British Aluminium Company, Ltd., near Fort William, a third pipe line was under construction from the Ben Nevis tunnel to the power station. The engineers for this work, as for the whole Lochaber scheme, are C. S. Meik and Halcrow, and the pipes are being erected by the South Durham Steel and Iron Company, Ltd.

Another project which came into prominence during the year was also rejected. During 1937 the supporters of the scheme for a barrage across the Thames in the neighbourhood of Woolwich managed to get the ear of the Government, and the Port of London Authority, which had never viewed the project with equanimity, agreed to the holding of an inquiry, over which, later, Sir Henry Maybury was appointed to preside. In all, five schemes were prepared to be placed before the inquiry, which was to have been held on March 29th, 1938. But a few days before it was due to open the Minister of Transport called a conference, which was attended by representatives of the Port of London Authority and the Thames Barrage Association and by Sir Henry Maybury. The Minister stated that the Government had recently received a report by the Committee of Imperial Defence. In the view of that Committee the scheme had serious disadvantages from the point of view of defence and in such circumstances the Government would be forced to veto any proposals put forward. The Port of London Authority consequently decided that no useful purpose would be served by the inquiry, which was therefore abandoned. The Thames Barrage Association still exists and has, we believe, the support of a few members of Parliament interested in the scheme.

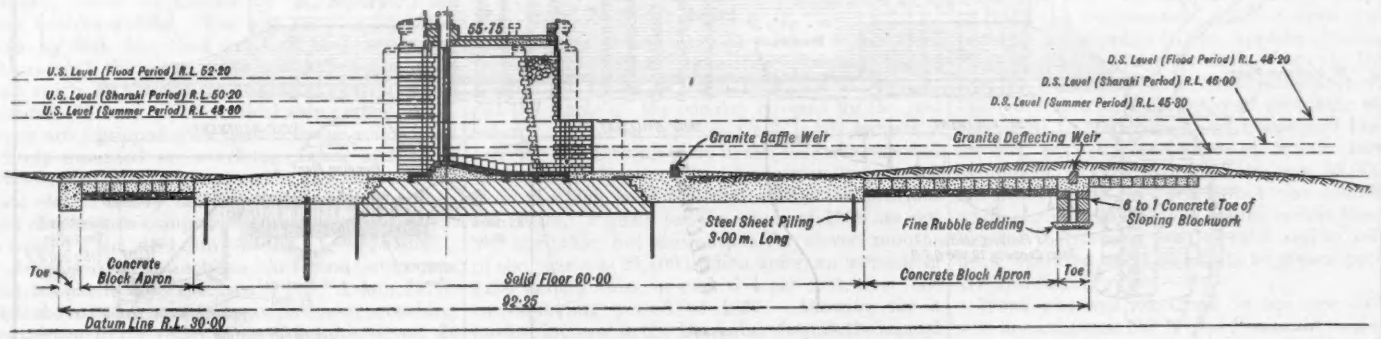
Only two works of any magnitude were in course of construction during the year. Both are concerned with water supply. The Haweswater dam, which will create a reservoir in the Mardale valley from which water will be drawn to serve the needs of Manchester, is under construction in the Lake District. It is a form of buttress dam, and at the end of the year about two-thirds of the total amount of concrete had been placed and four out of forty-four blocks had been completed to the full height. A recent photograph of the dam is reproduced in the Supplement accompanying this issue. In preparation for the time when the reservoir will be filled, certain farm and other buildings were demolished and timber felled and removed. Before the end of the year the recording instrument for measuring the flow of compensation and flood water was installed in a building below the dam designed to receive it. Work was also begun on the intake well and the valves, and pipes for the control of water



MODEL OF DAM UNDER TEST IN BELLEVUE LABORATORY


55·75
Approx. U.S. Level 52·00 (Flood Period Years 1925 to 1928)
Approx. U.S. Level 48·00 (Summer Period Years 1925 to 1928)
Approx. D.S. Level 50·00 (Flood Period Years 1925 to 1928)
Approx. D.S. Level 46·00 (Summer Period Years 1925 to 1928)
10·00 Paving
8·00
18·50
Apron
Solid Floor
Datum Line R.L. 30·00

TYPICAL CROSS SECTION OF EXISTING BARRAGE BEFORE REMODELLING.



CROSS SECTION OF BARRAGE AT VENTS NOS. 4 TO 30 INCLUSIVE AFTER REMODELLING.

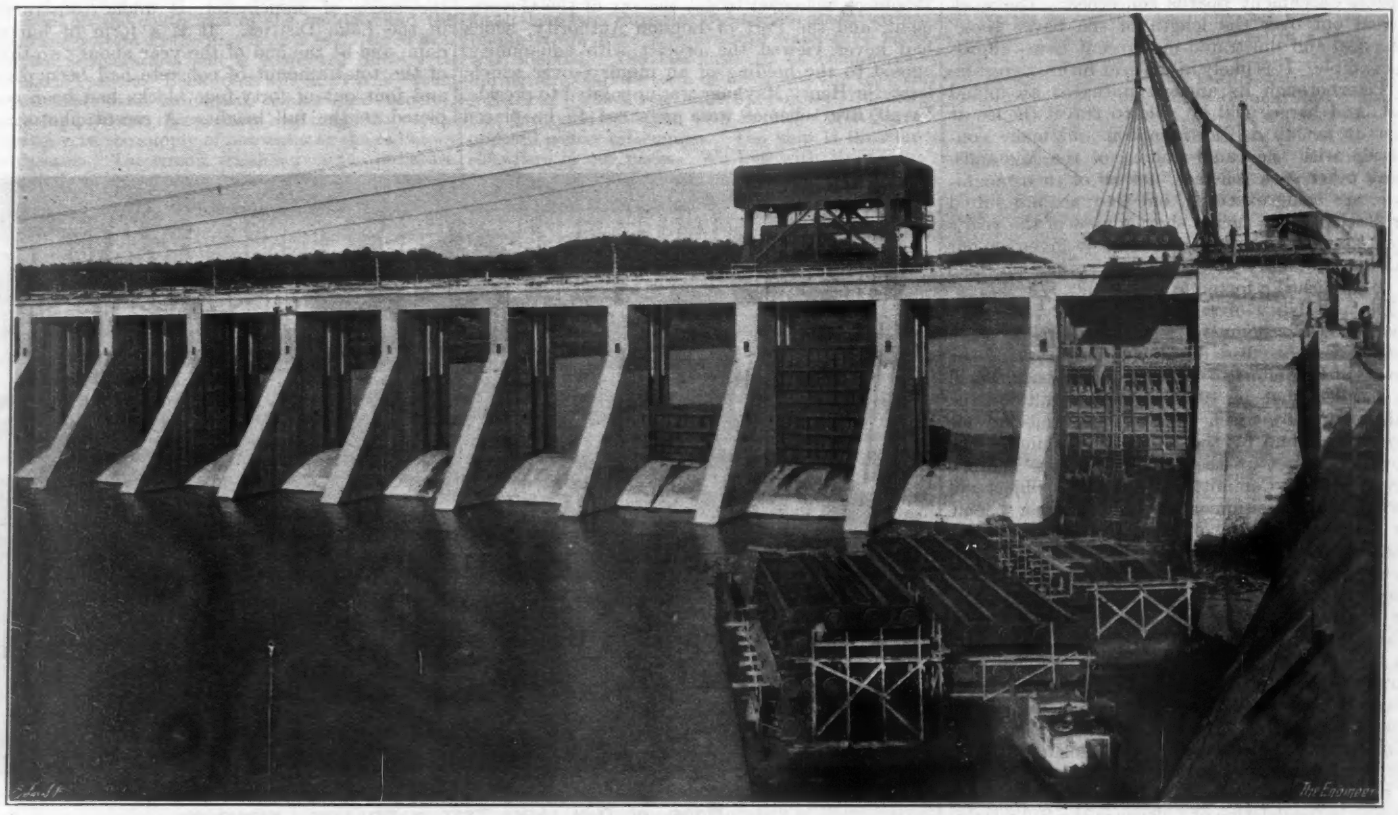
ASSIUT BARRAGE BEFORE AND AFTER RE-MODELLING

drawn off from the reservoir were fixed in position. The Ladybower reservoir, which is situated in the Peak district, is now under construction for the Derwent Water Board; it consists of an earthwork embankment with a concrete core wall across the valley. It will impound 6000 million gallons.

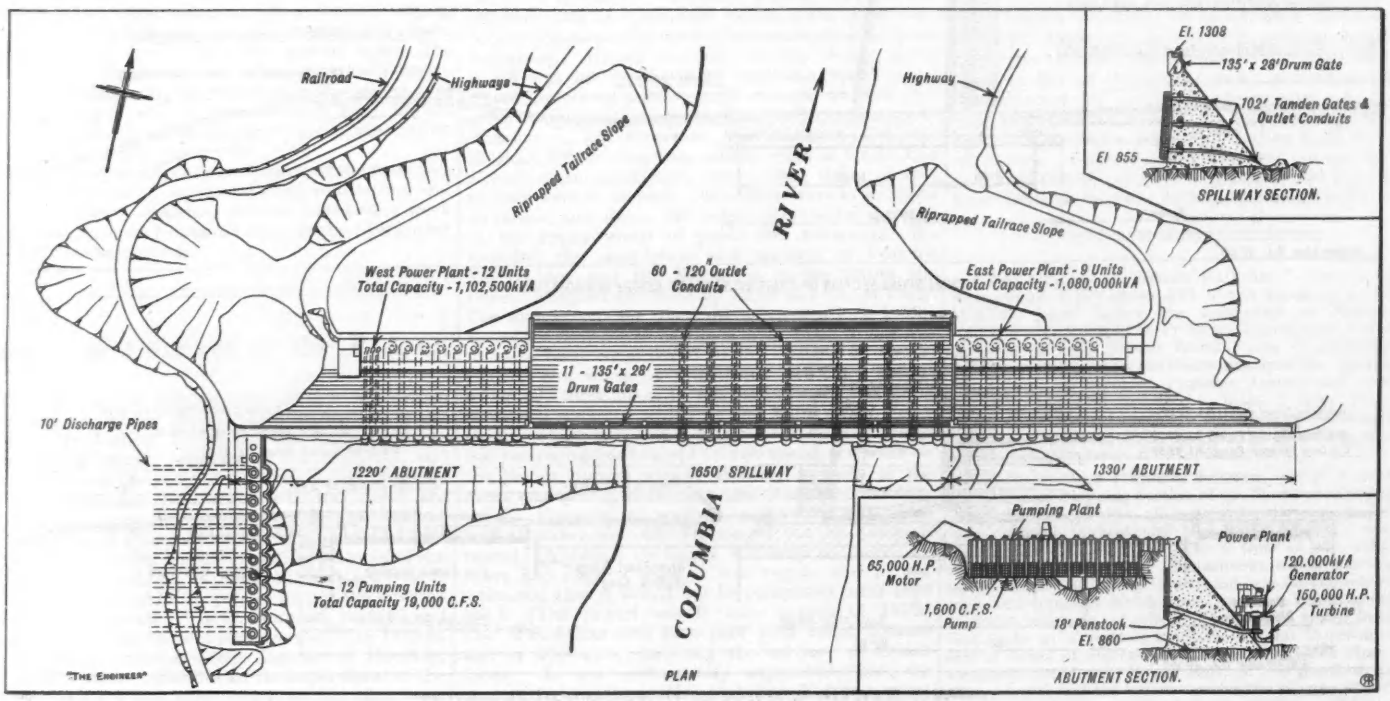
Foreign Schemes

A considerable amount of work was going forward in various countries of the world. In France, for instance, the Genissiat scheme, described and illustrated in our last issue of 1938, is notable as being probably the largest structure of its kind to be built in Europe, and for its points of similarity with the Boulder dam in America. Perhaps the more interesting matter to which to make reference is, however, the new dam and bridge research laboratory, the work of which was well under weigh during the year at the Office Nationale des Recherches et Inventions at Bellevue, near Paris. Equipment is now available which permits tests to be made on models of dams made of the actual material to be used in the finished structure and built to exact scale. The scale used varies, but is usually 13·6 to 1 or 20 to 1, and an accompanying engraving shows a model ready for test. Mercury is usually used to produce the pressure against the dam—hence the scale 13·6 to 1—and it is confined within a sack of balloon cloth. A number of instruments have been devised to measure the stresses, deflections, &c.

Egypt is a country of large dams and barrages intended to regulate the flow of the Nile, and it is seldom that some work is not in progress there. During 1938 the work of remodelling the Assiut barrage, which is one of those controlling the flow of water into the delta and was originally built in 1902, was completed under the direction of Messrs. Coode, Wilson, Mitchell and Vaughan-Lee, of Westminster, by the main contractors, John Cochrane and Sons. The chief object of the alterations is to take advantage of the additional storage available as a result of the raising of the Aswan dam in 1933 by raising the river level at the entrance to the Ibrahimia canal, thus enabling a constant supply of water to be maintained at all seasons instead of only during the flood. The Ibrahimia regulator was also altered to suit the changed conditions. The Assiut barrage is 800 m. long, and has 111 sluices. There is a lock, 16 m. wide and 80·10 m. long, at the western end. In order to permit the head on the barrage to be raised 4 m., the piers were lengthened on the downstream side in rubble masonry, and the arches similarly lengthened, new granite raised sills and floors were built and new sluices and grooves were provided. In addition, work had to be done at the lock. Its east wall was strengthened and widened, the downstream approach walls and the concrete floors at both ends were lengthened, and a new impermeable concrete floor was laid on the river side of the east wall. An engraving in the Supplement shows work in progress on the barrage. Four of the vents of the barrage are in process of having the new arches turned, whilst further along the original barrage is being cut down for the purpose of extending the piers. Typical sections



ERECTION OF GATES ON PICKWICK LANDING DAM—TENNESSEE VALLEY



PLAN OF GRAND COULEE DAM

before and after remodelling are shown by a line engraving on page 29.

This review is mainly concerned with works of considerable magnitude. But one small scheme is worth mentioning, since the power was obtained by harnessing one of the great waterfalls of the world. The idea of utilising the power of the Victoria Falls on the Zambesi River was first conceived more than thirty years ago, when it was suggested that the Rand might be supplied with current through an overhead line more than 700 miles long. The difficulty in transmitting current such a distance is almost insuperable at present. But despite the remoteness of the Falls from any large industrial centre, it has been found worth while to erect a power station to supply the requirements of Livingstone and any industries which may in consequence be attracted to the town. Two 1000-kW G.E.C. sets were installed during the year, and they are supplied with water from an intake a little above the Falls through a 3000ft. canal and a small pipe line. The power house is situated in the gorge close by the "Silent Pool," and on account of the hot conditions the machines and apparatus are designed to operate automatically, thus avoiding the necessity for the constant attendance of an engineer. Current is generated at 3300 volts, three phase, 50 cycles. The plans were prepared by Mr. George A. Stewart, consulting engineer to the Victoria Falls and Transvaal Power Company.

In America work is always proceeding on great schemes for the generation of hydro-electric power, for irrigation or water supply, or for the improvement of navigation, and more than one such scheme has combined all these qualities. But in this review we intend to refer only to three projects and schemes as examples. The Parker Dam on the Colorado River, 150 miles below Boulder Dam, was completed during the year. It is a concrete arch structure, 320ft. in height with a crest length of 930ft., and in the laying of the concrete special precautions had to be taken, owing to summer temperatures reaching levels as high as 110 deg. Fah., to protect freshly laid concrete from the evaporation of the water, by water sprays, painting, and other methods. The reservoir, 55 miles long, created by the dam, supplies thirteen cities on the Pacific coast with water through an aqueduct 392 miles in length. Work upon it was begun in March, 1934, but its completion was delayed by lengthy interruptions to the work.

One of the greatest of the many schemes under execution in America is that now being carried out by the Tennessee Valley Authority. The work, which consists principally of the construction of a series of dams, has as its objectives flood control, the improvement of navigation, and the generation of power. Originally, Army engineers mainly with the object of improving navigation on the river, proposed to erect no less than 149 low dams along its course. But the Authority, when it came into being, considered such a scheme objectionable on the grounds that it would give little protection against floods and that navigation would be hindered by the large number of locks. It was therefore decided to substitute a smaller number of high dams. In 1933 work on two such structures, the Norris and Wheeler dams, was begun, and at intervals thereafter the Pickwick Landing, Gunterville, Chickamauga, and Hiwassee dams were begun. Other dams are under construction or projected. All those so far built are gravity structures as far as the main portion is concerned, but the arrangement of penstocks and situations of the power stations vary in accordance with the peculiarities of the sites.

Early in 1938 steel spillway gates were installed in the Pickwick Landing dam, which has twenty-two spillway openings, and is illustrated by an accompanying engraving. All the gates were fabricated by the Dravo Corporation, of Pittsburgh; each is formed of a separate top and bottom section. The top sections are 41ft. wide by 20ft. deep, and weigh 40 tons, whilst the others with the same width are 20ft. 5 $\frac{1}{16}$in. deep and weigh, on account of the greater pressure to be resisted, 65 tons. The vertical side girders of the gates are equipped with double flange rolled steel wheels mounted on overhung axles, and these wheels, 30in. diameter, run on the gate tracks in the gate slots. Heavy fabricated silicon steel girders and diaphragms compose the framework, to which is welded a $\frac{1}{2}$in. steel shin plate.

Another American scheme, the Grand Coulee project, is a particularly spectacular one. A dam, 557ft. high above its lowest foundation, is now approaching completion in the valley of the Columbia River. It is 700ft. deep and about 2000ft. wide at this point. This river, which has a volume of flow only second to that of the Mississippi, rises in the Canadian Rockies and flows in a very meandering course in a more or less south-westerly direction to its mouth in the Pacific Ocean near Portland. The greater part of its course lies in the United States. Its waters are to be utilised to develop ultimately 2,700,000 H.P. and will be diverted to irrigate large dry areas in the Columbia Basin, which are potentially fertile, but which suffer at present from lack of rainfall. For the latter purpose the Grand Coulee, from which the scheme takes its name, is to be used. At the site of the dam the river flows from east to west. In the ancient past an ice barrier blocked the valley near this point and the pent up waters overflowed over the rocky floor of the neighbouring plateau southward. The Grand Coulee, a gorge 52 miles long with a maximum depth of 900ft. and a width ranging from 2 to 5 miles, was eroded by the river, which, when the ice barrier dissolved, returned to its old course, leaving the Coulee, the floor of which is 600ft. above the river bed, dry. A large part of the Coulee is now to be used as a storage reservoir with a capacity of 1,050,000 acre-feet, for the irrigation scheme. Water will be pumped into it from the storage in front of the dam by utilising the hydraulic power available and will be drawn off at its southern end into a network of irrigation canals serving an area of over 1,000,000 acres. The scheme was first authorised in 1933, but at that time only a low dam was envisaged. The project was altered to its present form in 1935, when the high dam arrangement was substituted. In an accompanying engraving a plan of the dam is reproduced, showing the situation of the power plant and the pumping plant. The arrangement of outlet conduits through the dam, shown in an inset, is interesting. The dam is a straight gravity structure and will maintain the reservoir normal water level at 1290ft. above sea level.

Electrical Engineering in 1938

No. I

THE difficulty of compressing a record of a year's electrical progress into a few of our columns does not diminish as the years roll by. The particulars we receive of work carried out and of orders secured by electrical manufacturers become more and more voluminous at the end of each twelve months, and the task of selecting the more important items is no light one. Electrical engineering has become a business with so many branches, that it is impossible to survey the whole field in the space allotted to these articles, or indeed entirely to cover even those branches in which our readers are most interested.

Although, taken as a whole, exports of all kinds during 1938 were appreciably below those of the previous year, during the first ten months of the period under review the exports of electrical goods, apparatus, and machinery amounted to £17·5 million, representing an increase of 18·6 per cent. over the corresponding figure for 1937. Exports of electrical goods and apparatus, valued at £11,053,000, increased by 17·3 per cent., while those of machinery rose by 42·4 per cent. The main increases were in telephone and telegraph apparatus, wireless transmitting apparatus, electrical instruments, generators, motors, and switchgear. Imports of electrical goods and machinery, valued at £4,004,000, were 25 per cent. lower than in the previous year.

At July the total number of insured workers between the ages of sixteen and sixty-four in the electrical manufacturing industry was 340,180, compared with 333,520 in July, 1937. The 1938 figure was made up of 117,710 people engaged in electrical engineering, 179,820 in the manufacture of cables, apparatus and lamps, and 42,650 engaged in wiring and contracting. Official figures relating to the number of workers actually employed in the electrical manufacturing industry during the last twelve months are not yet available, but it will probably be found that the number was less than in 1937, as the unemployment percentages were higher. In June, 1938, the unemployment percentages in electrical engineering, cables, apparatus, lamps, wiring, and contracting were 5·5, 9·1, and 10·9 respectively, as compared with the June, 1937 percentages of 3, 4·5, and 10·3, although after the month of June the employment position improved. For October the unemployment percentages in the three branches of the industry mentioned were 5·2, 6·7, and 9·5 respectively.

The Central Electricity Board

By the introduction on July 1st of a grid tariff for the North-East England area, trading by the Central Electricity Board became general throughout the whole of the country covered by the grid scheme. Slowing up of trade and industrial activity which began early in the year was reflected in the rate of electricity production, which fell from the high level recorded during the previous five years. Figures for the whole of 1938 are not yet available, but the output for eleven months of the year was 21,700 million units, an increase of 1296 million units, or over 6·4 per cent. over the corresponding period of 1937. Allowing for a modest increase in the December output, the annual figure should be well over 24,000 million units. Of last year's output it is estimated that over 97 per cent. was generated at stations now operated under the direction of the C.E.B. While no change was made during the period under review in the number of selected stations, in accordance with extension programmes planned in previous years the capacity of those stations was increased by the addition of some 700,000 kW of new generating plant and boilers with an aggregate capacity of 8,000,000 lb. per hour. The largest of the new generating units was an additional 60,000-kW set put into service at Fulham during the month of January. Sets rated at 50,000 kW were also put into service at the Barton, Hams Hall, Clarence Dock, Kearsley, Dalmarnock, Dunston, and Portishead stations. Supplies were also reinforced by new machines ranging from 37,500 kW to 20,000 kW at the Brighton, Portobello, Hartshead, Blackburn Meadows, Coventry, Hackney, Brimsdon, and Huddersfield stations.

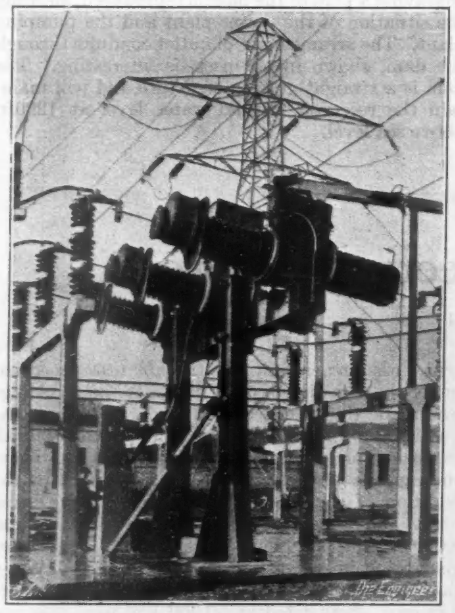
In fulfilment of its duty, the Board completed its survey of the situation for which provision must be made during the winters of 1940 and 1941, and made arrangements for a large proportion of the additional plant necessary to meet the peak demands during those years. With the approval of the Electricity Commissioners, it arranged with the authorised undertakers to increase the capacity of the selected stations by some 800,000 kW of generating plant and boilers capable of evaporating 11,000,000 lb. per hour, representing a capital outlay of approximately £14,500,000. The largest and most important addition to generating plant required for the winter of 1941–42 will be provided by a new selected station to be erected at Little Barford, Bedfordshire, by the Bedfordshire, Cambridgeshire, and Huntingdon Power Company. This station, which is now under construction, is intended to meet the rapidly increasing demands for electricity in the northern part of the South-East England area. It will have an initial installation of two 30,000-kW turbo-alternators and three boilers, each having an evaporative capacity of 300,000 lb. per hour.

Among the 1938 extensions to the grid transmission lines were the new 132,000-volt line from Leicester to Corby, reinforcing the supplies to the Kettering Urban District Council for the steel works of Stewarts and Lloyds, Ltd, and the 132,000-volt line from Upper Boat, Pontypridd, to Ebbw Vale, for the supplies given by the Ebbw Vale Urban District Council to the new steel works of Richard Thomas and Co., Ltd. At Scunthorpe a connection was made to the Grimsby-Hull 132,000-volt line to meet the requirements of the Scunthorpe Corporation for supplies to the Appleby-Frodingham Steel Works. A 132,000-volt line from the Lydney selected station of the West Gloucester Power Company to a new 132,000-volt switching station connected to the Cardiff and Portishead line was erected, with the exception of certain terminal equipment. Construction of the new 33,000-volt line from Neath to Port Talbot was completed; while the new 33,000-volt double circuit line from Kendal to Staveley was erected and is initially being operated at 11,000 volts to give supplies to Windermere.

Work was well advanced on the new 132,000-volt lines through the Wirral Peninsula connecting the existing grid sub-station at Percival Lane, Runcorn, with 132,000-volt sub-stations under con-

struction near Chester and Birkenhead. From the new Chester 132,000-volt sub-station supplies will be given by means of a new lower voltage line to the North Wales Power Company for the Shotton Ironworks of John Summers and Co., Ltd. Pending the completion of these works, a supply will be given over a line temporarily connected to the existing 33,000-volt line from Runcorn to Chester. Construction is also proceeding on the 132-kV line between Brighton and Worthing.

Preliminary surveys were completed and most of the wayleaves obtained for the 132,000-volt



IMPULSE CIRCUIT BREAKER

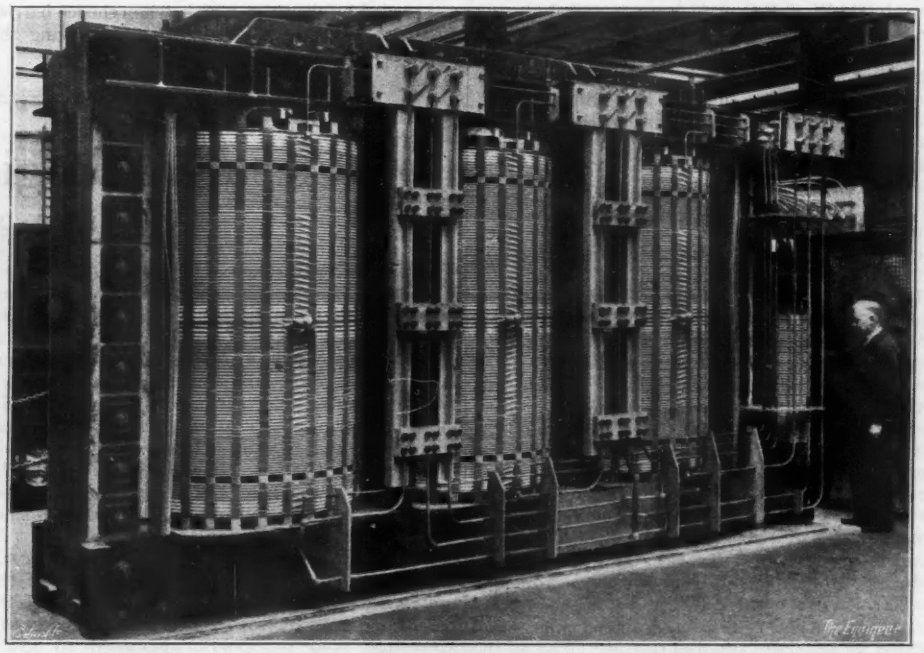
lines to be erected from the new selected station at Littlebrook, under construction by the Kent Electric Power Company, to Hastings and to the grid sub-station at Northfleet. Work was also begun on the new 132,000-volt line between Stourport and Worcester. Arrangements were made to string the second circuit of the 132-kV lines from Northfleet to Woking and from Ironbridge to Ocker Hill. From the latter, supplies will be given to the West Midlands Joint Electricity Authority.

Generating Plant

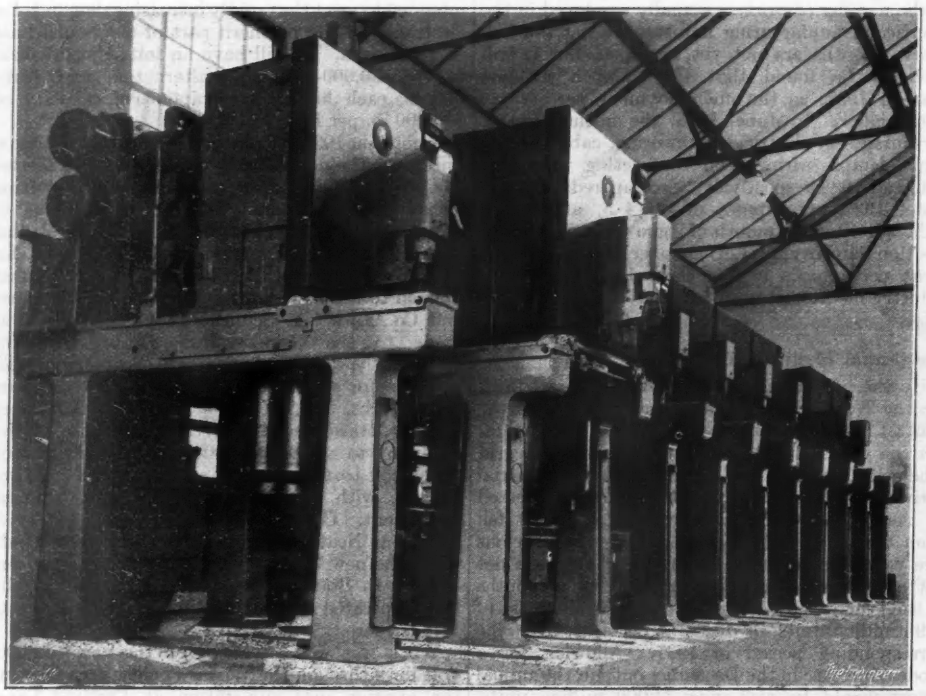
Some of the new turbo-generator sets put into service during 1938 are shown in one of to-day's Supplements and on page 20. A new three-cylinder, 30,000-kW, 3000 r.p.m., English Electric machine installed in the Blackburn Meadows station of the Sheffield Corporation is the third large machine the English Electric Company has built for that station. The steam conditions are 570 lb. per square inch, 828 deg. Fah., and 28½in. vacuum. At the Clarence Dock station of the Liverpool Corporation two new 50,000-kW machines to be seen in the background in our illustration of the station were installed by the Metropolitan-Vickers Electrical Company. While the original Metrovick machines work at 450 lb. per square inch and 800 deg. Fah., the new sets operate at 600 lb. and 800 deg. Fah. The most notable set from the point of view of steam conditions put into operation during 1938 was the 54,000-kW machine at the Brimsdown station of the North Metropolitan Electric Supply Company. Designed for a pressure of 1900 lb. per square inch and 930 deg. Fah., it is composed of two units. The two-cylinder primary unit, which receives the high-pressure steam, drives a 33-kV, 19,000-kW main generator and house service generator and operates in series with a two-cylinder condensing unit driving a 33-kV, 31,000-kW, alternator and a 3000-kW house service generator. Another set rated at 60,000 kW M.C.R. and designed for the same steam conditions, is being supplied for this station by the Metropolitan-Vickers Electrical Company. No trouble has been experienced with the company's 33-kV alternators, which now have an aggregate capacity of 200,000 kW. A set working at this voltage and put into operation during 1938 was a 51,250-kW machine installed in the Barton station of the Manchester Corporation. A fourth 33-kV, 50,000-kW B.T.H. turbo-alternator for the Ironbridge station of the West Midlands Joint Electricity Authority is under construction at the makers' Rugby works. Another machine illustrated is the 30,000-kW Parsons set put into operation at the Thorpe power station of the Norwich Corporation. It operates at 650 lb. per square inch and 850 deg. Fah.

Many other machines, apart from those illustrated, were, of course, put into service. Others are under construction. To cope with their growing business, extensions to C. A. Parsons' Heaton works were made. The demand for high-voltage turbo-alternators with concentric windings continues to increase. With the machines under construction the aggregate capacity of these alternators is now 1,054,450 kVA. Most of them generate at 33–36 kV, but the advantages of the concentric winding are not confined to these pressures, and two 50,000-kW machines for working at 20 kV have been built. One was put into commission during the year at the Dalmarnock power station of the Glasgow Corporation. A 30,000-kW machine generating at 36 kV was set to work in the Congella power station of the Electricity Supply Commission, South Africa. For the Hams Hall power station of the Birmingham Corporation the firm has in hand a pair of 53,500-kW units. Each machine will consist of a 50,000-kW, 33-kV main alternator and a 3500-kW house service alternator driven by the same turbine. Supply undertakings that have had experience with these machines are ordering others. A second 30,000-kW, 36-kV set is, for example, to be installed in the station of the Northampton Electric Light and Power Company, and a third set of similar output in the station of the Calcutta Supply Corporation. Another 30,000-kW, 36-kV turbo-alternator is in hand for the Derby Corporation. This machine is the fifteenth unit built for this Corporation since 1904, when C. A. Parsons supplied it with three D.C. turbo-alternators rated at 300 kW. Amongst the machines designed for ordinary voltage under construction is a pair of 50,000-kW, 11-kV units for the new station at Bunnerong for the Sydney County Council, New South Wales. These sets are said to be the largest built in this country for 3000 r.p.m. Other machines on order for foreign or overseas customers include a single-cylinder, 16,250-kW, 3000 r.p.m. unit, complete with condensing plant, for the City Council of Pretoria, a tandem, 7500-kW, 1500 r.p.m. turbine for the Central Argentine Railways, Ltd., a 5000-kW, 3600 r.p.m. "pass-off" turbine and condensing plant to work with steam at 800 lb. pressure and 800 deg. Fah., for the Ford Motor Company of Canada, Ltd., and a 1000-kW geared "Uniplane" turbo-alternator for Maryborough City Council, Queensland, Australia.

Many turbo-alternators were under construction at the Witton works of the General Electric Company including seven machines designed for a speed of 3000 r.p.m. with a capacity of 35,000-kVA and upwards. Two 40,000-kVA sets for the Johannesburg Municipality bring the total



45,000-KVA 132/33-KV TRANSFORMER UNDER CONSTRUCTION



33-KV DUPLICATE BUS-BAR SWITCHGEAR FOR DERBY

number of machines supplied by the company to this body up to nine. The alternator for a 37,500-kW set for Woolwich is being wound for 22 kV. Many G.E.C. turbo-alternators were built for industrial concerns.

Among the turbo-generator orders received by the British Thomson-Houston Company was one for a 30,000-kW, 3000 r.p.m. machine for the Ayrshire Electricity Board. The alternator is wound for 22,000 volts. Another large unit recently ordered is a 25,000-kW, 3600 r.p.m., double extraction turbo-alternator for the Ford Motor Company of Canada, Ltd. The turbine of this set is to be supplied with steam at 800 lb. per square inch and a temperature of 800 deg. Fah. Several large turbo-alternators are being erected, including a second 30,000-kW extraction unit for the Dagenham works of the Ford Motor Company, Ltd. Another turbo-alternator under construction is a superimposed unit for the Delray power station of the Detroit Edison Company. The turbine will take steam at 800 lb. per square inch, 900 deg. Fah., and will exhaust steam at 400 lb. per square inch into the steam heater feeding, in parallel with the low-pressure boilers, the existing sets in the station. Among the large machines completed during the year were a second 51,600-kW unit for the Kearsley power station of the Lancashire Electric Power Company, a third 30,750-kW set for the Longford power station of Coventry Corporation (both of which generate at 33 kV), and a 25,000-kW, 1500 r.p.m. machine for the Glasgow Corporation Transport Department. Several smaller back-pressure, mixed-pressure, and extraction sets were manufactured for industrial service. Other machines ordered or completed during the year were geared units of all types.

To the Stourport power station of the Shropshire, Worcestershire, and Staffordshire Electric Power Company the English Electric Company supplied two 30,000-kW sets and a third set of the same output is on order. The design of the three machines is identical. Each consists of a 3000 r.p.m., two-cylinder impulse reaction turbine, working at 625 lb. per square inch and 825 deg. Fah., and driving an 11-kV alternator. For the Huddersfield Corporation a 20,000-kW, 3000 r.p.m., two-cylinder turbo-alternator is being built for a pressure of 350 lb. per square inch and a temperature of 750 deg. Fah. A 7500-kW, 3000 r.p.m. English Electric machine will shortly be put into service by the Slough Trading Estates, Ltd. Smaller English Electric sets put into operation during the year include 2000-kW and 1250-kW back-pressure sets, supplied to the Ely and Kelham works of the British Sugar Corporation, and two 1600-kW units built for the Burntisland works of the British Aluminium Company. For the Ferrybridge station of the Yorkshire Electric Power Company the firm is building a 40,000-kW, 3000 r.p.m. unit. Other sets in the course of manufacture are for Australia, India, the Federated Malay States, and Palestine. Considerable technical developments were made by the company's turbine department including special blading for low pressures.

An important contract awarded to the Metropolitan-Vickers Electrical Company was for a 50,000-kW, 1500 r.p.m., 11-kV turbo-alternator for the Blackburn Meadows power station of the Sheffield Corporation. The set is to be a duplicate of the Metrovick two-cylinder unit ordered in 1936, operating with steam at 570 lb. per square inch and 825 deg. Fah. A 20,400-kW, 3000 r.p.m. unit is being built for the Prince's Rock power station of the Plymouth Corporation. The turbine is designed for 400 lb. per square inch pressure and 800 deg. Fah. Many repeat orders were received for machines for service abroad.

Switchgear

Demands for power on the Central Board's system, especially in the South-West Area, necessitated considerable modifications and extensions to the switching arrangements in that area, both as regards the switchgear itself and the protective equipment on the interconnected feeder circuits. The principal stations affected by these changes, the Metropolitan-Vickers Electrical Company informs us, have been the Upper Boat, Cardiff, Newport, Portishead, and Gloucester stations. The 132-kV switching station at Littlebrook is laid out for the accommodation of eighteen double bus circuits, of which eleven are being equipped during the first stage with high-speed impulse breakers, similar to those supplied for the Lydney station of the C.E.B. as illustrated, but fitted with more powerful mechanism to give a circuit-interrupting time of about three cycles to meet the greater short-circuit breaking capacity. In these breakers the energy required to extinguish the arc is supplied mechanically by the operating mechanism, whereas in the ordinary breaker the energy required for arc extinction is provided by the arc itself by causing turbulence or by forcing oil across the arc path. But the variation of arc energy with the current in that path is wide, and it is necessary to compromise between differing requirements on high and low currents. Since in the impulse breaker the energy for arc extinction is supplied by the mechanism, it is constant for each operation, regardless of the fault current. Many short-circuit tests made on these breakers have shown that within the limits of the design the arcing time is constant, and quite independent of the voltage or current. The main factor bearing on their operation is the rate of rise of restriking voltage of the system or test circuit. When the ratio of oil velocity to rate of rise exceeds a certain definite value interruption is certain. Compressed air activates pistons which separate the contacts and give the oil impulse. The speed of operation of this type of breaker is in the neighbourhood of three cycles, measured from the instant of the trip impulse to the moment of operation.

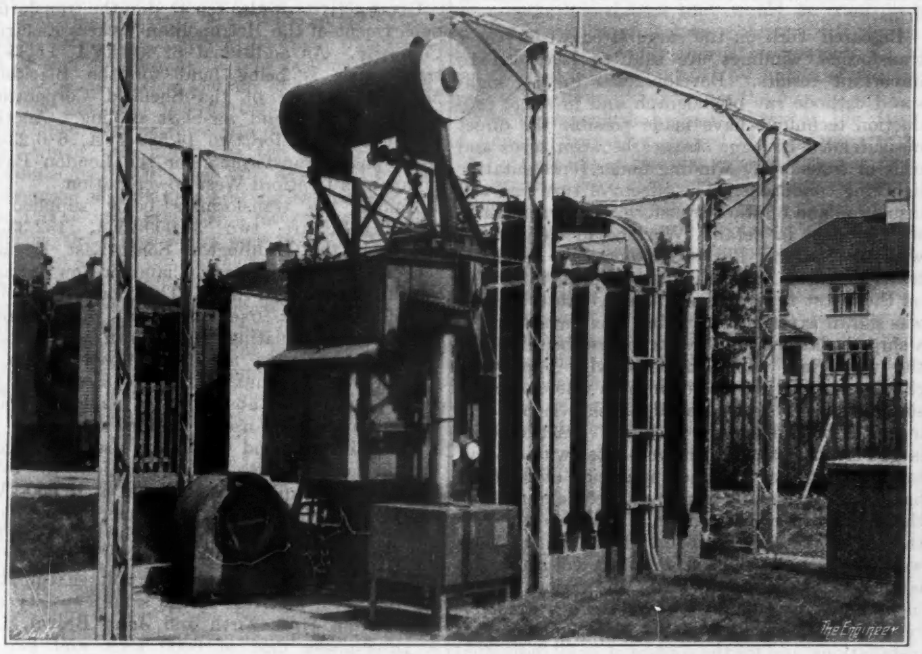
New 66-kV, 2000-mVA switching equipment is being made by the Metropolitan-Vickers Electrical Company for the Battersea "B" station. Single break metal-clad gear is to be used and the contract covers seventeen circuits, involving the supply of twenty-five breakers.

The single-break circuit breaker has been adopted for installation in cubicle types of switchgear where switches of greater breaking capacity than those existing are required and where space is limited. But apart from extensions to existing installations, the more conventional forms of metal-clad units are still required in many cases. The new switch-rooms at Aberdeen are being equipped with thirty-three of these units, in anticipation of this station being connected to the Central Board's system in the near future. Extensions calling for the supply of the larger frame sizes of metal-clad units are being made at Bolton, Coventry, Stepney, and at the North-West Midlands Joint Authority stations. Many smaller Metrovick switches, required chiefly for use with auxiliaries and consumers' supplies, were made. Much work was done in the way of modernising circuit breakers by fitting them with cross jet pots. The demand for switching equipments gave rise to activity in the company's control board section. Several large control board contracts were completed during the year. Increased activity in the metal trades, both at home and abroad, was also reflected in the number of control boards for mill equipments operating on the Ward Leonard system.

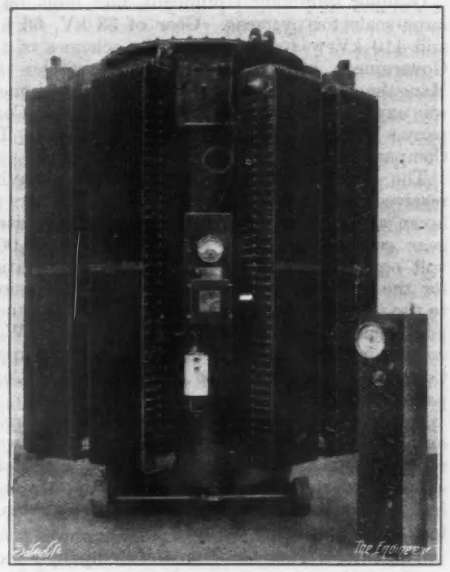
A. Reyrolle and Co., Ltd., carried out many switchgear contracts at home and overseas. In this country the more important contracts were for 60-kV switchgear for the Kent Electric Power Company's Littlebrook station, 33-kV gear for the Leicester Corporation's Freeman's Meadow station, and 33-kV switchgear for the Birmingham Corporation's Hams Hall "B" power station. In each case these are new stations of considerable importance, and small oil volume metal-clad units are being used for the first time. Switchgear work was secured in many parts of the world, and particularly important business was obtained in Australia, New Zealand, South Africa, India, Canada, in the Far East and the Near East, and South America.

While the use of arc control pots on the General Electric Company's circuits has been confined in the past to units of large capacity, in view of the fact that conditions of service are constantly becoming more severe, it has been decided to fit such pots to breakers of smaller capacity. This has enabled the maximum capacity of the range of breakers known as "Subgear" to be increased without much increase in dimensions, and it has also resulted in a much reduced arcing time. Many of the 132-kV, 1500-mVA circuit breakers supplied to the C.E.B. have been modernised by fitting arc control pots, and as a result their breaking capacity has been made considerably greater. A sample breaker fitted with the new arc control pots has been tested according to the B.S.S., Part 2, 1937, to a capacity of over 2000 mVA.

The development of G.E.C. heavy metal-clad gear was advanced by the completion of a large board composed of 11-kV, 1000-mVA units for the Clydes Mill power station of the Clyde Valley Electric Supply Company. The breakers are notable for their high breaking and making capa-



TRANSFORMER DESIGNED FOR LOW NOISE LEVEL



LARGE VOLTAGE REGULATOR

city of 52·6 kA and 134 kA respectively. The normal current is 2000 amperes. Each breaker has a motor-operated oil-immersed bus-selector switch, and in accordance with the makers' standard practice the bus-bars consist of condenser bushings, which reduce the amount of inflammable oil or compound.

An important addition to the equipment of the G.E.C. high-power testing station is a low voltage testing transformer, which enables tests to be made, either single-phase or three-phase, at any voltage between 220 and 3300 volts. At voltages up to 660 an output of 75,000 kVA can be obtained without any special circuit arrangements. To the switchgear testing equipment, a medium power testing station, capable of carrying out short-circuit tests on D.C. apparatus up to a maximum of 3 kV, and on A.C. gear up to 1·2 kV, has been added. The maximum short-circuit capacity at present available is about 60,000 amperes direct current at 750 volts and about 25,000 kVA alternating current. The impulse testing of lightning arresters, transformers, and switchgear has been facilitated by the installation of a new recording cubicle in the high-tension test house. This contains as its principal component a large and extremely sensitive metal tube cathode ray oscillograph, designed and made in the firm's development department. Its superiority over the sealed glass type of instrument previously used for this work can be estimated from its writing speed, if required, which can attain a value of about 200 miles per second; while the sharpness and clearness of the wave trace give greatly improved accuracy.

Outdoor switching equipment was built on a large scale for overseas. Gear of 33 kV, 66 kV, and 110 kV was supplied for the schemes of the Government of Madras; 110 kV switches for Mangahao, New Zealand; and similar equipment was exported to the Bremant Gold Dredging Company, West Africa, and the Anglo-Burma Tin Company.

The English Electric Company reports having received many repeat orders from customers at home and overseas. Extra high-voltage switchgear contracts include 88,000-volt and 66,000-volt equipments, a new 132,000-volt sub-station for the Central Electricity Board, and extensions to the 66,000-volt cellular switchgear at the Stourport generating station of the Shropshire, Worcestershire, and Staffordshire Electricity Supply Company, installed by the English Electric Company in 1937.

In the low-voltage field extensions were carried out at Portsmouth and annual contracts were renewed by a number of municipal electricity supply undertakings. The company is establishing a new research department and switchgear testing station at its Stafford works.

The British Thomson-Houston Company's technical developments during 1938 were mainly in the direction of improvements in the performance of high-voltage oil circuit breakers. With the improvements in design, coupled with higher opening speeds, the most recent breakers have total break times of three cycles, from 100 to 30 per cent. rating. This advance in performance is associated in certain designs with the introduction of a single break instead of the conventional double break. Pneumatic operation of oil circuit breakers has also been adopted to obtain higher closing speeds, and to eliminate the large battery necessary to ensure that a breaker will make its rated peak current.

A new range of 22-kV and 33-kV metal-clad, compound-filled, indoor switchgear, rated 750 mVA, 1000 mVA, and 1500 mVA, was evolved. This gear embodies important improvements, including single break oil circuit breakers, isolated phases so arranged that the phase components on the stationary portion are separable, small compound content in the chambers, condenser type bus-bars, and testing sheaths on all condenser insulation.

A new design of the company's Class Q A gear has been developed. Although it is entirely air insulated, all conductors are covered by moulded insulation where they are not enclosed in porcelain, and a breaker lifting and lowering device is incorporated on each equipment. Other developments include improvements in the design of flameproof 440 to 3300-volt draw-out switchgear; a new three-compartment ring main equipment; and simplification of synchronous motor starting switchgear to ensure easier starting and automatic disconnection if a fault occurs on the starting compensator.

During the year many orders were obtained for all types of B.T.H. switchgear for use in this country and abroad, but having devoted so much space to the switchgear contracts and developments, we cannot refer to them individually. The 33-kV metal-clad duplicate bus-bar switchgear illustrated was built by the B.T.H. Company for the Full Street generating station of the County Borough of Derby.

Transformers and Voltage Regulators

Business in the transformer section of the industry was also good. Among the large units manufactured by Ferranti, Ltd., were two 45,000-kVA, 132-kV transformers, making a total of thirty-two Ferranti units of that rating or over on the grid system. Units rated at from 10,000 to 20,000 kVA are on order. For extensions at the Battersea power station of the London Power Company the firm is supplying two 87,000-kVA 66-kV transformers and others of smaller outputs. Several banks of 40,000-kVA, 88-kV transformers and some 2500-kVA, three-phase units are being supplied to South Africa. High-power 250-kV testing transformers are on order for cable making firms.

Research work on the surge strength of power transformer windings are said to have led to important results. Developments in the high-speed cathode ray oscillograph and in surge production technique have made possible the direct measurement of surge stresses between turns and coils of transformer winding under representative lightning conditions. The effects of turn and coil insulation and of other transformer characteristics were studied in detail. Working in conjunction with the National Physical Laboratory, the Electrical Research Association made an investigation on the latest type of Ferranti surge absorber. It was shown experimentally that the wave front of a surge is flattened by the surge absorber and that the wave tail was also flattened. The latter characteristic is important in cases where a severe surge has been chopped by the flash-over of a live insulator or transformer bushing. Practically all large Ferranti transformers were fitted with on-load tap-changing gear and the application of this gear has for a considerable time past been extended to the smaller distribution units of smaller ratings by the use of mercury switches. Development work was also carried out on Ferranti voltage regulators, which are now made in various forms, including a self-contained pillar type, a street pit type, a simple form of regulator for house service installations, and for the control of small individual loads. A large three-phase regulator giving 20 per cent. voltage range on a 11,000 volts 7500-kVA circuit is illustrated.

An additional 60,000-kVA, 132/33-kV transformer unit ordered by the C.E.B. for the Ironbridge grid sub-station is being supplied by the British Thomson-Houston Company, making four B.T.H. units of this rating at this station. Progress was made by the company in the application of shields to high-voltage windings to obtain improved stress distribution under impulse conditions. The number of B.T.H. shielded winding transformers installed and on order is now 162, with an aggregate capacity of 380,000 kVA. Furnace and rectifier transformers are also in demand. The call for reduced noise levels has been met by special constructions. Development work on this matter is continuing, and distribution engineers are co-operating in the research work being done by the B.T.H. Company. An 18,000-kVA, 33/11-kV transformer, designed for low noise level installed at Cairn's Road sub-station of the Bristol Corporation is shown on page 33.

Among the many transformers built by the General Electric Company was a 45,000-kVA, 132/33-kV five-limbed outdoor unit, illustrated in the course of construction. Up to half load the transformer is cooled by natural circulation of the oil through two separately mounted banks of tubular radiators, whilst at higher loads an air blast is directed on to the tubular radiator surfaces by high-pressure centrifugal fans. Tappings on the high-voltage windings give a variation of plus or minus 10 per cent. and fourteen steps of 1·43 per cent. Remote-controlled motor-operated on-load tap-changing gear is fitted at one end of the tank. Fourteen 1000-kVA, single-phase transformers with on-load tap-changing gear are being built for New Zealand.

Bruce Peebles and Co., Ltd., supplied two 30,000-kVA, 132-kV transformers with on-load tap-changing gear for the Scottish grid, two 15,000-kVA units with on-load tap-changing gear, and twenty-five transformers in various sizes, totalling 20,500 kVA for Scottish public supply authorities, transformers aggregating nearly 30,000 kVA for a Scottish electricity supply company, and a large number of units for use abroad.

Great activity is also reported in the transformer department of the Metropolitan-Vickers Electrical Company. An additional 62,500-kVA, 11/33-kV transformer is being built for the Blackburn Meadows station of the Sheffield Corporation. It has natural and air-blast cooling. Another repeat order is for two 14,583-kVA, 6·6/23-kV single-phase transformers for the London Power Company's Deptford West power station.

Among the transformers being supplied to the C.E.B. are two 30,000-kVA, 132/33-kV units for the Beddington South-East England scheme. Transformers are in hand for New Zealand, South America, and India. The company supplied transformers for overseas filled with a non-inflammable insulating fluid known as Troffodol. These transformers are of compact design to minimise the amount of fluid required, and the tanks contain gas absorbers to make the transformers suitable for use in confined spaces.

C. A. Parsons and Co., Ltd., also report good transformer business. In addition to other large units completed was a pair of 15,000-kVA, 33/11·33-kV three-phase transformers with on-load voltage regulating equipment for the Sheffield Corporation; a pair of 10,000-kVA, 33/6·6-kV three-phase units with automatic voltage regulation for Bradford, and one of the same capacity and voltage for Thos. Firth and John Brown, Ltd. A three-phase unit of 6000 kVA and two of 3000 kVA head a long list of transformers supplied to the North-Eastern Electric Supply Company, Ltd., while four 5000-kVA, 21/6·6-kV three-phase units with on-load voltage regulators for the Metropolitan Electric Supply Company, Ltd., are representative of those supplied to other undertakings in the country. Overseas deliveries included a large order for India.

Although the demand for large transformers during 1938 was not as great as in the past, the English Electric Company secured, in common with other firms, orders for such transformers including two 20,000-kVA units for the grid. The demand for small transformers up to 500 kVA increased. There was also an increase in the use of small 33-kV distribution transformers which are coupled to the lines without protection. English Electric transformers with on-load tap-changing gear now have an aggregate capacity of 3½ million kVA. Additional large reactors are being supplied for use on the grid. A bank of 132-kV reactors being made for the Board will give 10 per cent. reactance no 50,000-kVA at 132-kV.

(To be continued.)

Harbours and Waterways in 1938

No. I

THE disturbed condition of international relations throughout 1938 had the effect of stimulating activity among the great Naval Powers in making increased provision for fleet accommodation in ports. This fact is noticeable not only in Great Britain, but also in the United States and Japan. Few capital works of individual magnitude were begun in home ports during the year, and it is only in the Port of London and at Liverpool that dock works of considerable magnitude are in process of construction at the present moment.

In Germany the extension and enlargement of inland waterways are being pushed on with great activity, particularly in connection with the Rhine–Main–Danube navigation project.

A former President of the Institution of Civil Engineers, who for many years had been a prominent figure in connection with harbours and waterways in Great Britain and Ireland, Sir John Purser Griffith, died in October at the age of ninety-one. He was largely responsible for the making of the modern port of Dublin. Mr. Gerald

Gascoigne Lynde, who died on August 1st, was responsible as a contractor with Edmund Nuttall, Sons and Co. (London), Ltd., for the construction of many important works in British and Colonial ports. He succeeded Lord Cowdray as President of the Federation of Civil Engineering Contractors in 1926.

The international crisis of the autumn directed the attention of port authorities and others to the problems which might be expected to arise in the event of a European war. One of these problems, to which some consideration has already been given and which requires full attention, is the probable—almost certain—diversion of a large volume of seaborne traffic from East Coast to West Coast ports in the event of war. Are existing facilities adequate to meet this contingency?

BRITAIN AND IRELAND

The Port of London

A year ago we referred to the progress made by the Port of London Authority with its programme of works, announced in May, 1936, estimated to cost nearly £12,000,000. The remodelling of the Royal Victoria Dock, which forms an important part of that programme, is now nearing completion, and some further sections of the new quays were brought into use during the year. The undeveloped area at the south-east corner of the dock, which was known as the Mudfield site, covering some 27 acres, has been developed by the construction of a quay wall on the south side of the dock, 1200ft. in length, with a return quay wall of 560ft. length. These works were begun in August, 1936, when a contract was placed with Sir Robert McAlpine and Sons, Ltd. The quays comprise mass concrete walls founded on concrete monoliths, and the depth of water which has been provided in front of both quays is 31ft. at impounded water level. These works were completed in September 1938, at a cost of £124,000. The reconstruction of the south quay at the west end of the Royal Victoria Dock was completed in the summer of 1937 by J. Mowlem and Co., Ltd., as contractors, and the deepening of the passage between the dock and the adjoining Royal Albert Dock was finished about the same time. The Port Authority then proceeded to remodel the north side of the Victoria Dock, where the existing accommodation comprised five jetties, built about eighty years ago, which afforded very inadequate accommodation. The remodelling was begun in January, 1937, when contracts were placed with J. Mowlem and Co., Ltd., for the quay construction and with the Tilbury Contracting and Dredging Company, Ltd., for the removal of the jetties, dredging, and other work. The new works comprise a continuous open-type reinforced concrete quay about 3250ft. long, with five modern three-storey warehouses, each 504ft. by 150ft. The cost of the works, including crane equipment, is estimated at £1,200,000. The quay work is expected to be completed in February, 1939. The quay deck, 45ft. wide, is carried upon three rows of reinforced concrete cylinders, each cylinder enclosing a group of reinforced concrete piles. The depth of water in the deepened dock is 31ft. at impounded water level. The erection of the five three-storey warehouses and the construction of roads and railways and other ancillary works at the Royal Victoria Dock were authorised by the Port Authority in May, 1938.

The widening of the east quay of the Millwall Dock and the construction of new two-storey warehouses will, it is expected, be completed early in 1939. This dock is being dredged to give a depth of 29ft. below impounded water level alongside the widened quay.

Progress is also being made with the re-equipment of several of the Port Authority's docks. Twenty-five 3-ton electric quay cranes were ordered recently for the West India Docks. An automatic coaling plant was provided at the Royal Albert Dock basin and the complete electrification of that dock is now being carried out. Eight new electric quay cranes of 3 tons capacity were ordered for the north quay of the King George V Dock. They will have a radius of 80ft., considerably greater than that of most dockside cranes in normal use.

Mr. J. D. Ritchie, formerly solicitor to the Authority, succeeded Sir David Owen in September as general manager of the Port of London Authority. Mr. W. P. Shepherd Barron, until recently the chief engineer of the Port of Karachi, was appointed to succeed Mr. Asa Binns on his retirement from the office of chief engineer to the Authority in May last.

The veto on the transport of petroleum spirit in bulk beyond Thames Haven, which was formerly imposed by the Port Authority, was removed in the course of the year by the approval by the Minister of Transport of new by-laws relative to petroleum spirit. The limit formerly was the Mucking Light, 8 miles below Gravesend. Vessels carrying petroleum spirit in bulk are now permitted to go as far up the river as Purfleet on the Essex bank, and Crayfordness on the Kent shore. It is understood that this extension of facilities, which has hitherto been opposed by the Port Authority, has been made on representations from the Government, that, having regard to considerations of national defence, facilities for storage in bulk must be made available higher up the river.

The inquiry which was to have been opened on March 29th last by Sir Henry Maybury into the proposal to construct a barrage across the Thames at Woolwich, or at some other point below Tower Bridge, was abandoned at the instance of the Minister of Transport on the eve of the hearing. In the light of a report made by the Committee of Imperial Defence, the Government had decided that they would be compelled to veto any such project as a barrage if it should be promoted. Several alternative projects for a barrage had been submitted by unofficial parties prior to the date appointed for the inquiry.

The twenty-ninth annual report of the Port of London Authority showed that shipping to a total of over 62½ million net registered tons arrived and departed from the port during the year ended March 31st, 1938. This figure is an increase of more than 10 million tons over the traffic of ten years ago. The tonnage of imports and exports for the financial year is a record for the port, namely, 44,643,644 tons.

A proposal to construct a yacht harbour at Southend-on-Sea was revived during the year and the Southend Council decided to obtain the advice of consulting engineers on the practicability and cost of constructing a sheltered harbour in the neighbourhood of the Southend pierhead.

The Mersey

The improvement of the West Waterloo Dock at Liverpool at a cost of £732,000, begun by the Mersey Docks and Harbour Board in June, 1937, is expected to be completed sometime in the autumn of 1940. The new entrance lock from the river is 450ft. long by 65ft. wide, and will have a depth over its cill of 17ft. 6in. at low-water spring tides. The river approach to the lock is to be dredged to 19ft. below low-water datum. The work is being carried out by direct labour. The conversion of the old dry dock in the Princes' Dock for use as a wet dock, which was also begun in June, 1937, has been completed. During the year ending July 1st, 1938, the Board deposited 439,549 tons of stone from their Welsh quarries on the training banks and over 14¼ million tons of sand were dredged in the sea channels.

For some years past there has been in progress an investigation, carried out under the direction of the Department of Scientific and Industrial Research, into the effect of the discharge of crude sewage on the amount and nature of the deposits in the estuary of the Mersey. This investigation, costing £26,000 and covering the chemical, hydrographical, and biological aspects of the subject, has now been completed, and a report on it was issued by the Department of Scientific and Industrial Research in April, 1938.* It was suggested by the Mersey Docks and Harbour Board, as well as by other interested parties, that the nature of the material deposited in the sea channels in Liverpool Bay is so altered by the presence of sewage in the water as to increase the difficulties and the cost of dredging. The rate of sedimentation of solid matter in suspension in the river is, it was suggested, increased by the presence of sewage matter. The report, in answer to the Board's question contained in the terms of reference, states that "the crude sewage deposited in the estuary of the River Mersey has no appreciable effect on the amount and hardness of the deposits in the estuary." The report is of great interest to harbour authorities.

The annual report of the Manchester Ship Canal Company for 1937 showed that the traffic on the canal reached in that year the record total of over 7 million tons. Improvements at the Stanlow oil depôt were completed during the past year, and a slipway for handling lock gates under repair was constructed at Runcorn.

* Water Pollution Research Technical Paper No. 7. H.M. Stationery Office, 1938: 30s. net.

The North-East Coast and Humber Ports

The project of the Tyne Improvement Commissioners for the improvement and development of their recently acquired property at Tyne Dock is now estimated to cost a sum approaching £900,000. A contribution in aid of this work has been promised by the Commissioner for Special Areas, and preliminary work on the reconditioning of the existing dock and building new quays therein has already begun. The Commissioners in December invited tenders for the construction of a new quay at the north-west corner of the dock. New traffic offices are being built, the road approaches have been improved, and the equipment of the existing dock is being modernised.

The channel of the River Tyne from the sea up to the riverside quay at Tyne Dock, which the Commissioners propose to construct in the near future, is to be deepened to 35ft. at low water of spring tides, and a similar depth will be afforded alongside the quay itself, which will probably have a river frontage of about 1400ft.

Another improvement which the Tyne Commissioners have in hand is the removal of the old coal staith and rocky point which project into the river and restrict the channel at Felling. In addition to considerable dredging in normal river bed material, the widening involves the removal of about 36,000 tons of hard sandstone by submarine blasting and dredging. The Commissioner for the Special Area is assisting this work also.

The extension of Newcastle Quay, for which the Newcastle-upon-Tyne Corporation obtained parliamentary powers in 1935, was completed; work was begun in March, 1936. This extension of 630ft. increases the total length of quayage owned by the Corporation to 7278ft. The structure is of reinforced concrete, 70ft. wide, and is supported on piles, those at the front of the quay being driven in groups inside reinforced concrete cylinders 9ft. diameter, sunk to just below dredged level, which is 30ft. below low water of spring tides.

The large flour mill and grain silo which Spillers, Ltd., has erected on the land side of the extension of the Corporation quay, was completed and is now in use. We referred to this structure in our review of a year ago. The mill building is over 170ft. in height and comprises twelve floors. Grain is discharged at the quayside by a Simon travelling pneumatic intake plant. One plant is already working and another is being constructed. The capacity of the silo is over 150,000 quarters of wheat.

The River Wear Commissioners completed during the year the building of a fish quay, fish market and stores at Holmes' Wharf, Sunderland, at a cost of about £45,000. The Commissioners have recently entered into an agreement with T. W. Greenwell and Co., Ltd., the owner of a large ship repairing and dry docking establishment at Sunderland, to take a long lease of the old No. 1 Graving Dock, which is the property of the Commissioners. The agreement provides for the early reconstruction of the dry dock by the lessee. The Commissioners have also decided to spend £65,000 on the improvement of the harbour entrance channel by deepening and straightening. Rock excavation in the channel forms a considerable part of the work to be done.

On July 2nd, Sir Josiah (now Lord) Stamp opened the new entrance lock at Goole, which has been constructed by the Aire and Calder Navigation. The new lock, now known as the Ocean Lock, is 375ft. long internally and 80ft. wide with 25ft. depth of water over the cill at high water. It is considerably larger than either of the two previously existing locks, which give access to the Goole Docks. The approach to the lock from the river is flanked by a pier structure.

During the year the London and North-Eastern Railway began work on the deepening of the old No. 1 and No. 2 Fish Docks at Grimsby to afford a depth of water equal to that in the modern No. 3 Fish Dock opened in 1934.

Some progress was made with the Seal Sand reclamation project, which is being carried out by the Tees Conservancy Commissioners. The work is being done by direct labour and will take about six years to complete. Over one-half of the 300 acres proposed to be won from the River Tees has already been reclaimed.

Southern Ports

On October 12th, 1938, the Southern Railway Company celebrated the centenary of the laying of the foundation stone of Southampton Docks. Mr. R. Holland Martin, the chairman of the company, on that day unveiled a memorial column,

bearing a suitable inscription, recording the laying of the foundation stone of the first dock and the commemoration of the centenary. The dock, now known as the Outer Dock, was opened in 1842. It was built by the Southampton Dock Company, incorporated in 1836, which remained in possession of the dock property until 1892, when the dock estate was taken over by the London and South-Western Railway, now merged in the Southern Railway Company. It is interesting to compare the expenditure of £9,000,000 incurred by the Southern Railway in recent years, mainly in connection with the extension of the dock system along the water front of the River Test, with the modest investment of £5000 made over a century ago by the original promoters of the dock undertaking in the purchase of 216 acres of land at Southampton. The first dry dock at Southampton, now being repaired and renovated, was opened in 1846 and a second wet dock, now known as the Inner Dock, was completed in 1851.

The new roads and railways serving the reclaimed area of the Western Docks extension at Southampton were completed during the year. The railway company has announced that a widening by 35ft. of the existing Itchen quays, south of the entrance to the Empress Dock, is about to be begun. This quay, about 1600ft. in length, comprises the berths known as Nos. 34 to 36 inclusive.

The Southern Railway also announced in October that improvements are to be carried out at Folkestone Harbour designed to give much-needed increased shelter to passengers embarking and disembarking at the quays on either side of the harbour pier. These works, which will cost about £50,000, are expected to be completed during 1939.

The Southern Railway Company is also carrying out works at Shoreham Harbour, Sussex, including the provision of a new quay at the Kingston Wharf, and at Lymington, where a quay for the motor car ferry service to the Isle of Wight has been constructed.

The failure of the Corporation of Portsmouth to come to terms with the Treasury and the Air Ministry in connection with the finance of the projected seaplane base in Langstone Harbour resulted in the decision of the Air Ministry to establish a flying boat terminal base at Southampton. It was announced towards the end of July that agreement had been arrived at between the Air Ministry and the Southampton Harbour Board, as a result of which statutory powers would be sought for the reservation of an area of water in Southampton Water for the use of aircraft. The objections to the use of a water area adjoining and inconveniently restricted by the navigable waterway are obvious, and the decision to establish an air base at Southampton Water is, in all probability, in the nature of a temporary measure pending the provision of a more ample and suitable base for overseas flying boats.

An offer has since been made, on behalf of a private syndicate, to the Portsmouth City Council to establish a seaplane base at Langstone as a private enterprise; but when this proposal came before the Council on December 15th, 1938, the Admiralty intervened and intimated in a letter addressed to the Lord Mayor of Portsmouth that "so far as can be foreseen, any scheme for utilising Langstone Harbour for an air base must be incompatible with the maintenance of essential naval services in the Portsmouth area."

A small harbour is being made at Maseline Bay in the Island of Sark, a contract for which was placed in May, 1938. The work is expected to take two years to construct.

Bristol Channel

The Port of Bristol Authority has invited tenders for the extension of the eastern arm of the Royal Edward Dock at Avonmouth, to which we made reference a year ago. The work includes an extension of the dock arm by 1100ft., with a reinforced concrete wharf on either side of the extended arm, the construction of jetties, and dredging.

Scotland

The Clyde Navigation Trustees continued the deepening and widening of the River Clyde, begun in 1937 in anticipation of the launching and passage down the river of the "Queen Elizabeth." Approximately 400,000 tons of material were dredged from the river to enable the launch, on September 27th, 1938, to take place and to provide adequate depth of water in the fitting-out berth at Messrs. John Brown's yard. For the passage of the "Queen Elizabeth" down the river the Clyde Trustees are now engaged on two important dredging and widening operations. The Dalmuir bend is being flattened for ½ mile and the navigable channel there is being widened by about 80ft. This work involves the dredg ng of about half a million tons of material. It was here that the "Queen Mary" touched during her passage down the river in 1936. The second work is the widening of the channel by about 100ft. for 1½ miles between Erskine Ferry and Bowling Harbour. The "Queen Elizabeth" will have a draught exceeding that of the "Queen Mary" when she left the Clyde.

The chairman of the Clyde Trust, at a recent meeting of the Trustees, raised the question of the present division of authority in the control of the River Clyde. In addition to the Clyde Trust, authority is exercised by the Clyde Lighthouse Trustees, the Greenock Harbour Trust, and the Port Glasgow Harbour Trust. The question of co-ordination and possible unification of control was referred to a committee for investigation and report. A somewhat similar proposal for the unification of the control of the Tyne port facilities under the Tyne Improvement Commissioners has recently been put forward for consideration.

The Meadowside granary extension, now practically completed by the Clyde Navigation Trust at a cost of about £110,000, has a capacity of 15,000 tons of grain. This figure, added to the capacity of the adjoining granary building, will give a combined storage of 46,000 tons.

The reconstruction of the Lancefield Quay, begun in June, 1937, is expected to be completed in 1940. The new quay will have a length of 925ft. The Clyde Trustees are carrying out the work by direct labour; the cost will be about £160,000.

The dry dock of the Ailsa Shipbuilding Company, Ltd., at Troon, has been enlarged and improved. The dock was reopened in August and now has an internal length of 400ft., and an entrance width of over 56ft.

The Aberdeen Harbour Commissioners are carrying out repairs to the South Breakwater, which recently suffered severe storm damage, This structure is 1050ft. long, and in February, 1937, a breach was made in it by the sea. Further damage followed and during 1937–38 the breach was closed at a cost of over £37,000. The Commissioners in July last approved a further expenditure of £80,000 on repair work to the breakwater, including the construction of a new face wall on the seaward side.

Ireland

The enlargement and improvement of the port works at Galway, which were mentioned in our review of the year 1937, are now expected to be completed not earlier than March, 1940. The work was begun in October, 1937, and includes a new entrance to the dock, a large amount of rock breaking, and dredging, and the deepening of the approach channel. The total cost is estimated at £200,000.

The Belfast Harbour Trust began early in the year the extension of the east quay of the Pollock Dock by 460ft. There will be a 30ft. depth of water at L.W.O.S.T. in the berths alongside the quay. A site adjoining the quay has been leased for the erection of a large grain silo.

The Government of Northern Ireland has offered £225,000 towards the expenditure of £400,000 to be incurred by the Belfast Harbour Commissioners in deepening a part of the harbour channel to enable the Belfast shipyards to undertake the construction of larger merchant and war ships. The Government has also arranged to assist in financing harbour works at Londonderry and Coleraine.

Naval Dockyards

Apart from expenditure at Singapore the 1938 Naval Estimates, presented in March, consisted almost exclusively of expenditure at home ports so far as constructional work is concerned. The No. 6 dry dock at Chatham is to be lengthened by an addition of about 160ft. At Plymouth additional storage accommodation is to be provided, and at Portsmouth workshop extensions are proposed. Oil fuelling depôts, both at home and abroad, are to be extended.

In November the question of the future of Pembroke Dockyard was raised in the House of Commons. In reply to questions, it was stated that the Government did not propose at present to reopen the yard for naval purposes. Pembroke was placed on a care and maintenance basis in 1925. On December 7th the Parliamentary Secretary to the Admiralty stated in reply to a question in the Commons that it had been decided to reopen the dockyard at Rosyth on a limited scale. Rosyth, it will be recalled, was also placed on a care and maintenance basis in 1925, and has since then not been used for naval purposes. The recent announcement by the Australian Commonwealth Government of its intention to construct a naval dock and yard at Sydney is mentioned hereafter.

Other Ports of the United Kingdom

The Maryport Harbour Commissioners received in June an intimation that the Commissioner for Special Areas had offered to make a contribution, partly in the form of a free grant and partly by loan, towards the cost of reconditioning Maryport Harbour. The work, however, has not yet been begun, and the harbour, the entrance of which is said to be in a dangerous condition, has recently been closed to shipping.

The work of reconditioning and remodelling Whitehaven Harbour, for which financial assistance had been given from the Special Areas Fund, was begun early in the year.

The London, Midland and Scottish Railway has placed a contract with Vickers-Armstrongs, Ltd., for two pairs of new dock gates to replace those at the Ramsden Dock entrance and at the lock entrance at Barrow. The railway company is also extending the water area of the Buccleuch Dock at Barrow.

Inland Waterways of the United Kingdom

On September 27th Dr. Leslie Burgin, the Minister of Transport, opened the new warehouse of the Grand Union Canal Company at Birmingham which constitutes an important addition to the equipment of the Canal Company's inland ports. The active policy which the Canal Company has pursued in recent years has resulted in a considerable increase in the canal traffic between Birmingham and London and the journey has been reduced from a week to forty-four hours.

Several of the English River Catchment Boards are busily engaged in carrying out river improvement works, most of which have as their main object flood prevention and the discharge of land water, and have only minor connections with the improvement of navigation.

The River Nene Catchment Board is engaged on a large scheme of river improvement and lock reconstruction. Below Wisbech, in the tidal compartment of the River Nene, the channel has been dredged, and the river improvements, reconstruction, and enlargement of locks, and dredging already carried out or in progress above the port of Wisbech will, when completed in about two years' time, enable 100-ton barges to navigate between Northampton, where junction is made with the Grand Union Canal, and Peterborough. Vessels of up to about 300 tons will be able to go up the river from Wisbech as far as Peterborough. The total cost of the river improvements included in the Catchment Board's scheme will be about £750,000. Over 50 per cent. of the cost is being borne by the Ministry of Agriculture and Fisheries.

The programme of works on which the River Trent Catchment Board is engaged, begun in 1936 and expected to be completed in 1943 at a cost of approximately £600,000, includes a large amount of river work which will have the effect of improving the navigation of parts of the River Trent, both above and below Nottingham.

(To be continued.)

PERSONAL AND BUSINESS ANNOUNCEMENTS

M. AND C. SWITCHGEAR, Ltd., Kirkintilloch, Glasgow, has appointed Mr. Jas. M. Hodge assistant to its London manager, Mr. W. D. Murray, at 36, Victoria Street, Westminster, S.W.1.

SORDOVISO, Ltd., makers of non-tilting mercury switches and control gear, have altered the name of their company to "Sordoviso Switchgear, Ltd." The company's head office and works remain at 220, The Vale, Golders Green, London, N.W.11.

MR. C. B. M. DALE, A.M.I.A.E., at present chief designer of Petters, Ltd., oil engine manufacturers, of Yeovil, has, upon the transfer of the technical staff to the Brush Electrical Engineering Company, Ltd., of Loughborough, taken up a similar position with that company.

THE INTERNATIONAL TIN RESEARCH AND DEVELOPMENT COUNCIL has moved its office from 378, Strand, to Fraser Road, Greenford, Middlesex. New laboratories are in course of erection on the same site, and further extensions of the Council's activities are planned.

MARSHALL, SONS AND CO. (SUCCESSORS), Ltd., Gainsborough, has acquired the road roller business of John Fowler and Co., of Leeds, and also their subsidiary company in India. Arrangements have been made to continue the manufactre of these road rollers at Gainsborough.

FERGUSON-BROWN, Ltd., Huddersfield, inform us that it has been considered advisable to segregate the Ferguson and Brown interests in the firm so that no confusion will arise in certain markets. To facilitate this arrangement, Mr. Ferguson has disposed of his shareholding in Ferguson-Brown, Ltd., to Mr. David Brown, and the title of the firm will be altered to David Brown Tractors, Ltd.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer. A comprehensive list of the prices of materials mentioned below will be found on the next page.

Our Steel Trade with Norway

The "Report on Economic and Commercial Conditions in Norway" to September, 1938, published by the Department of Overseas Trade, price 2s. net, states that in 1937 there was an expansion in the total value of imports, and the increase in the imports from Great Britain was well above the average. There was also a strong advance in the shipments to Great Britain. In the case of imports from Great Britain, however, the situation was not particularly favourable, as, apart from the trade in old ships, coal, coke, and whale oil, this country failed on the average to maintain her position in the Norwegian market. The imports of iron and steel into Norway had risen 38 per cent. between 1933 and 1935 and increased again to over 42 per cent. from 1935 to 1937. From January to July, 1938, however, these imports declined by over 50 per cent. compared with the corresponding period of 1937. The Report states that after Great Britain had joined the International Steel Cartel importers placed large orders for many months ahead in anticipation of a rise in prices. At the same time, the demand for steel for armament purposes further stimulated the market, and although prices were repeatedly raised merchants and consumers in Norway as well as in other countries purchased heavily for fear of being left without supplies. In May, 1937, the situation changed and during the remainder of the year, as well as the first part of 1938, Norwegian importers placed few orders. Their surplus stocks had, however, in the main been disposed of by the summer of 1938 and new business was again being done more freely, except in shipbuilding material. At the end of August, 1938, importers in Norway were holding back as they expected that the Cartel would reduce its price to meet Swedish competition. Great Britain lost business to Belgium in galvanised corrugated sheets and in 1938 it was reported that low prices had been quoted by French mills. There was a considerable increase in the imports of tin plates in 1936–37, but most of the business was done by the United States and Germany, Great Britain's share being comparatively small. Owing to the modernisation of plant and great industrial activity there was an increase in the demand for machinery, tools, and engineering supplies, and the value of the imports rose in 1937 by 32·5 per cent. Germany and Sweden are the most important suppliers of electrical machinery and apparatus, and as regards other machinery Germany retained one-third of the trade and made increased sales of Diesel and heavy oil engines, textile machinery, and printing machinery.

The Pig Iron Market

The last month of the year was disappointing so far as the volume of trade was concerned, although in the last week of December there was an encouraging increase in the amount of inquiry for delivery in 1939. In a number of cases consumers have entered the New Year with contracts uncompleted, but nevertheless there is a more cheerful tone in the foundry pig iron market than for several months. In this section the amount of inquiry has exceeded expectations, and it is anticipated that a good proportion will result in business. Expectations that an increase in the demand would result in more furnaces going into operation have been fulfilled by the starting up this week of another unit on Cleveland foundry, as well as one on basic iron. During the last six months of 1938 the production of foundry iron on the North-East Coast has been intermittent, and the resumption of a regular output of this quality is an encouraging feature of the situation. The demand is still restricted by extensive stocktaking operations, and it will probably be at least a fortnight before the prospects for the first quarter of 1939 can be gauged with any accuracy. This week many consuming works in the Middlesbrough district have been in partial production owing to the extended holidays, so stocks in makers' yards may show a temporary increase. In the Midlands the light castings foundries which have allowed their reserves to fall to a very low level have already entered upon a number of contracts and there has been a quite healthy amount of inquiry in circulation. The makers of high-phosphoric pig iron, therefore, are starting the New Year under moderately favourable conditions, although their chief customers, the light castings founders, are by no means well employed. In this district, however, there is an active demand for low-phosphoric iron from the engineering foundries. Although the price of this material is not controlled, there has been a slight upward movement and recent transactions have been entered upon at £5 7s. 6d. to £6, according to analysis and tonnage. In Lancashire a rather limited business has passed, although the stocks at consumers' works are understood to have been reduced to a minimum. In Scotland deliveries have been suspended for the New Year break, and until these holidays are out of the way there is not likely to be much business transacted in pig iron. Holiday influences are still apparent in the hematite pig iron market. Deliveries have been largely suspended since Christmas and as a consequence the stocks in the producers' hands have increased. It is anticipated, however, that by the middle of January the demand for this material will expand. The prospects in the basic pig iron market are not so favourable as in other sections. Most of the steelmakers carry stocks of this description and there is still a considerable tonnage of Indian iron to be received against contract. As a result consumers are not keen upon entering into forward contracts.

The Midlands and South Wales

Most of the steel works in the Midland area recommenced operations at the beginning of this week, but the market was still affected by holiday conditions and stocktaking. The New Year, however, has opened with a fairly active inquiry and both buyers and sellers are inclined to take an optimistic view of the outlook in the early part of 1939. It is not anticipated, however, that a very large volume of business will be transacted until, at least, the middle of January. Probably the semi-finished products section of the market will be the first to reflect the reduction in prices, as most of the consuming works have been buying on a restricted scale for several weeks past. Stocks are low and the inquiry from the re-rolling section of the industry has been on an encouraging scale since the price reductions were announced. Constructional engineers are expected to provide a good outlet for joists and sections in the coming weeks, since, in common with other branches of the trade, they have been holding aloof from the market in anticipation of lower prices. The plate makers are probably as well off as any section of the steel industry as regards orders on their books, and they anticipate the development of a fresh demand during the present month. The sheet industry experienced a very dull demand practically throughout 1938, but the announcement that steel shelters are to be provided for A.R.P. has encouraged expectations of a large demand for this material. The sheet makers, however, depend largely upon the export demand and there are few signs of any improvement in this direction. There is still a considerable amount of controversy over the new rebate scheme which is to be applied to colliery material. The rebate will be extended to arches, roofing bars and light rails. In this case the price has been reduced by 12s. 6d. per ton, but the rebate of 15s. will be added to the new price and returned to consumers buying only from the associated makers. Quiet conditions continue to rule in the South Wales market and the position in the tin-plate trade is arousing some concern. The orders upon the makers' books are a little over two million boxes, or about 50 per cent. of the total at the beginning of 1938, whilst the works before the holidays were operating at 43·93 per cent., against 76·27 per cent. of capacity in the corresponding week of 1937. The poor state of the tin plate trade, naturally, reacts upon the demand for sheet and tin plate bars. Other branches of the steel trade in South Wales have entered the New Year with poor order books and are eagerly awaiting the expected trade revival.

Current Business

The London and North-Eastern Railway has placed a contract with A. Jackaman and Sons, Ltd., Slough, for the widening of the waterway between St. Andrew's Dock and Extension, Hull, the provision of a new swing bridge, and improvements to the access to the fish docks. The body-building department of the Brush Electrical Engineering Company, Ltd., Loughborough, will, owing to the expansion of the business, operate in future as a subsidiary company under the name of Brush Coachwork, Ltd. This is part of the general reorganisation programme of the company to divide its activities into three main groupings. The Brush Diesel-engine and Petters oil-engine business, recently acquired, constitutes the second group, and the third will comprise the production of turbo-alternators, transformers, and other electrical power plant. An order for a motor cargo ship for the British Channel Islands Shipping Company has been secured by the Burntisland Shipbuilding Company, Ltd. W. H. A. Robertson and Co., Ltd., Bedford, makers of rolling mill plant, have been given an order by the Outokumpu Copper Company, of Finland, for a cold-rolled strip mill. The London, Midland and Scottish Railway has decided to construct at its own works 100 shock-absorbing wagons of 12 tons capacity for the conveyance of special traffic. This follows the successful introduction of this type last summer. New foundry buildings are to be erected by the Croydon Foundry, Ltd., ironfounders, at 66, Purley Way, Waddon, Surrey. E. A. Brough and Co., Ltd., iron drum manufacturers, Liverpool, are erecting a works on the municipal industrial estate at Speke. The Bristol aeroplane engine factory is to be extended. A large foundry will shortly be in operation and a new machine shop has already been completed. The Government has decided to establish a Royal Ordnance factory at Dalmuir, Glasgow, on the site formerly occupied by the shipyard of Wm. Beardmore and Co., Ltd. This yard was taken over some years ago by National Shipbuilders Security Ltd. It is officially announced that the production of the Canadian mines in 1938 was valued at 440,634,000 dollars, or 4 p.c. less than in 1937.

Copper and Tin

A rather firm tone developed in the electrolytic copper market in the closing days of 1938, but this is not an unusual tendency at the end of the year, and is usually welcomed by consumers and those carrying stocks, as it gives the balance sheet a more favourable appearance. No fundamental change occurred in the condition of the market, however, and holiday influences have prevailed in practically all the principal consuming countries. In the United States the official price has been maintained at 11·25c. d/d, but it seems probable that when the statistics are published consumption in December will show a decline compared with that for November, as the domestic sales to December 20th amounted to just short of 10,400 tons. Most consumers in America appear to be fairly well covered, and there does not seem to be any anticipation of a revival of active buying for the first few weeks of the New Year. Continental buyers also have held aloof from the market, but it is anticipated that there will be renewed buying by European countries once the stocktaking and holiday influences are out of the way. The market seems to be convinced that the demand is only in abeyance and will develop fresh strength before the end of the month. There is still some tightness in the prompt copper position, although the stocks in London Metal Exchange warehouses at December 31st showed a rise when compared with the figures for the end of November. The total of rough copper increased from 24,792 tons to 25,054 tons, and of refined from 3521 tons to 4533 tons. Rather steady conditions have ruled in the standard copper market. Expectations that there will be a general improvement later in January appear to have led to a certain amount of speculative buying, but the account has by no means assumed unwieldy proportions. . . . Disappointment felt in the last few days of the year at the absence of American buying of tin was removed this week by large purchases, which are reported to have amounted to over 1000 tons. Apart from this buying, however, the demand has been rather quiet and the Continent has shown comparatively little interest in the market. The statistics published by Mr. W. H. Gartsen show an increase of 617 tons in the visible supply. This is attributed to the comparatively low American deliveries for December. There was an increase of 179 tons in the carry-over in the Straits at 6947 tons, whilst at the Arnhem Smelter the carry-over showed a decline of 834 tons to 1649 tons. Supplies during the month totalled 6454 tons compared with 7086 tons in November. The deliveries amounted to 5837 tons compared with 7460 tons in November. Of the December figure the Continent took 630 tons, the United States only 3400 tons and Great Britain 681 tons.

Lead and Spelter

Lead, like other non-ferrous metals, developed a strong tone at the end of the year, but there is a general inclination to discount this movement as being rather artificial and due to stocktaking influences. At the same time, the undertone in this market does not seem very confident, and there is a tendency to regard the future with some doubt. To a certain extent this is due to the decline in building operations and to the resulting diminution in the demand for building materials in which lead plays an important part. At the moment the supplies available for the market appear to be in excess of requirements, and this has created some surprise as it was generally thought that by the New Year the producers' restriction of output scheme would be exerting some influence upon the position. The speculative account in this market is comparatively small and the closing of some accounts in the last week of the old year had a rather depressing effect. For the next week or two it is doubtful if consumers will show any great interest in the metal, but the market may expect to develop more strength towards the end of the month when stocktaking is over. In the meantime, there is comparatively little forward buying, but a fair business appears to have been transacted with those users who have been obliged to enter the market, but have bought only sufficient to cover their immediate requirements. . . . The slightly better appearance of the spelter market at the end of the year was not maintained, and this week fresh easiness developed in the price. This market is suffering from the poor industrial demand. Anticipations are current that the requirements of the galvanisers may increase as a result of the business they may receive from the Government's new A.R.P. schemes, but to what extent galvanised sheets will enter into these precautions remains to be seen. The brass makers, however, are fairly well occupied and should provide a moderately good outlet for spelter during the coming weeks. There is also a fair demand from the manufacturers of bearing metals. The demand is still principally for high-grade spelter, and there has been comparatively little business transacted in G.O.B. quality. Supplies in this market have been on a liberal scale for some time, and the London Metal Exchange official warehouse stocks at the end of December totalled 25,381 tons, made up of 6809 tons duty free and 18,572 tons in bond, compared with 24,124 tons at the end of November, which included 3029 tons duty free and 21,095 tons in bond.

Non-ferrous Metal Average Prices

The dull conditions which ruled in the non-ferrous metal markets during the greater part of December are reflected in declines in the monthly average prices issued by the London Metal Exchange in every department excepting tin. The official average quotation for cash copper for December fell by £1 8s. 4d., compared with that for November, whilst for three months the figure was £1 15s. 8d. lower, the settlement price being £1 16s. 5d. less than the November average. The average quotation for electrolytic copper for December was £2 2s. 1d. less than in the previous month, and for wire bars £2 2s. 4d. down. The average for best selected copper shows a reduction of £2 0s. 6d., compared with the November average. The price for cash tin, however, is 10s. 8d. up on the November figure, whilst for three months the price rose by 14s., the settlement average being 10s. 9d. better than that for November. In the case of lead the average for shipment during the current month was 19s. 8d. below the November figure, whilst for shipment in the third following month it was 18s. 11d. down, the mean being 19s. 4d. lower and the average settlement price 19s. 5d. below the average for November. The December average price for spelter for shipment during the current month was 13s. 1d. below the November average, whilst for shipment in the third following month it was 1s. 9d. less, the mean being 13s. 5d. lower. The average price for settlement was 13s. 3d. lower than the November figure. The following are the official average prices for December :—

STANDARD COPPER ...	Cash (mean)	£43	9	4½
	3 Months (mean) ...	£43	14	1½
	Settlement	£43	9	3
ELECTROLYTIC COPPER (mean)		£49	8	1½
ELECTROLYTIC COPPER WIRE BARS		£49	16	6
B.S. COPPER (mean)		£49	4	2
STANDARD TIN	Cash (mean)	£214	11	7½
	3 Months (mean) ...	£215	11	1½
	Settlement	£214	10	9
LEAD — For shipment the current month (mean)		£15	2	1½
LEAD — For shipment the third following month (mean)		£15	5	6
LEAD — Mean		£15	3	9¾
LEAD — Settlement		£15	2	3
SPELTER — For shipment the current month (mean)...		£13	14	2¼
SPELTER — For shipment the third following month (mean)		£13	17	2½
SPELTER — Mean		£13	15	8 7/8
SPELTER — Settlement		£13	14	0

Current Prices for Metals and Fuels

Makers' official home trade price, per ton, delivered buyers' stations. *Joists, Sections, Bars and Plates are subject to a rebate of 15s. to home users purchasing only from Associated British Steelmakers. † Export prices are for Empire Markets; for other Markets British quotations conform to Cartel prices.

PIG IRON.

Foundry home prices, except for Scotland, less rebate of 5/-

	Home.	Export.
	(*D/d Teesside Area.*)	
N.E. COAST—	£ s. d.	£ s. d.
Hematite Mixed Nos.	6 0 0	—
„ No. 1	6 0 6	5 15 0
Cleveland—		
No. 1	4 19 0	5 2 6
No. 3 G.M.B.	4 17 6	5 0 0
No. 4 Foundry	4 7 6	—
Basic	4 12 6	—
MIDLANDS—		
Staffs—	(*Delivered to Black Country Station.*)	
North Staffs. Foundry	5 1 0	—
„ „ Forge	4 16 0	—
Basic	4 12 6	—
Northampton—		
Foundry No. 3	4 18 6	—
Forge	4 15 6	—
Derbyshire—		
No. 3 Foundry	5 1 0	—
Forge	4 18 6	—
SCOTLAND—		
Hematite, f.o.t. furnaces	6 0 6	—
No. 1. Foundry, ditto	5 8 0	—
No. 3 Foundry, ditto	5 5 6	—
Basic, d/d	4 12 6	—
N.W. COAST—	6 0 6 d/d Glasgow	
Hematite Mixed Nos.	6 6 0 „ Sheffield	
	6 12 0 „ Birmingham	

MANUFACTURED IRON.

	Home.	Export.
LANCS. AND YORKS.—	£ s. d.	£ s. d.
Crown Bars	12 5 0	—
Best Bars	12 15 0	—
MIDLANDS—		
Crown Bars	12 5 0	—
Marked Bars (Staffs)	15 15 0	—
No. 3 Quality	10 17 6	—
No. 4 Quality	11 7 6	—
SCOTLAND—		
Crown Bars	12 5 0	12 5 0
Best	12 15 0	12 15 0
N.E. COAST—		
Crown Bars	12 5 0	12 5 0
Best Bars	12 15 0	12 15 0
Double Best Bars	13 5 0	13 5 0
NORTHERN IRELAND AND EIRE STATE—		
Crown Bars, f.o.q.	12 17 6	—

STEEL.

	*Home.	†Export.
LONDON AND THE SOUTH—	£ s. d.	£ s. d.
Angles	10 10 6	10 0 0
Tees	11 10 6	11 0 0
Joists	10 10 6	10 0 0
Channels	10 15 6	10 5 0
Rounds, 3in. and up	11 10 6	11 0 0
„ under 3in.	11 17 6‡	11 0 0
Flats, under 5in.	11 17 6‡	11 0 0
Plates, ¾in. (basis)	10 15 6	10 2 6
„ ⅞in.	11 0 6	10 7 6
„ 1in.	11 5 6	10 12 6
„ 1⅛in.	11 10 6	10 17 6
Un. ⅞in. to and incl. 6 lb. per sq. ft. (8-G.)	11 12 6	12 10 0
Boiler Plates, ¾in.	11 5 6	11 12 6
NORTH-EAST COAST—	£ s. d.	£ s. d.
Angles	10 8 0	10 0 0
Tees	11 8 0	11 0 0
Joists	10 8 0	10 0 0
Channels	10 13 0	10 5 0
Rounds, 3in. and up	11 8 0	11 0 0
„ under 3in.	11 15 0‡	11 0 0
Plates, ¾in. (basis)	10 10 6	10 2 6
„ ⅞in.	10 15 6	10 7 6
„ 1in.	11 0 6	10 12 6
„ 1⅛in.	11 5 6	10 17 6
Un. ⅞in. to and incl. 6 lb. per sq. ft. (8-G.)	11 12 6	12 10 0
Boiler Plates, ¾in.	11 0 6	11 12 6
MIDLANDS, AND LEEDS AND DISTRICT—	£ s. d.	£ s. d.
Angles	10 8 0	10 0 0
Tees	11 8 0	11 0 0
Joists	10 8 0	10 0 0
Channels	10 13 0	10 5 0
Rounds, 3in. and up	11 8 0	11 0 0
„ under 3in.	11 16 0‡	11 0 0
Flats, 5in. and under	11 15 0‡	11 0 0
Plates, ¾in. (basis)	10 13 0	10 2 6
„ ⅞in.	10 18 0	10 7 6
„ 1in.	11 3 0	10 12 6
„ 1⅛in.	11 8 0	10 17 6
Un. ⅞in. to and incl. 6 lb. per sq. ft. (8-G.)	11 12 6	12 10 0
Boiler Plates, ¾in.	11 3 0	11 12 6

STEEL (*continued*).

	*Home.	†Export.
GLASGOW AND DISTRICT—	£ s. d.	£ s. d.
Angles	10 8 0	10 0 0
Tees	11 8 0	11 0 0
Joists	10 8 0	10 0 0
Channels	10 13 0	10 5 0
Rounds, 3in. and up	11 8 0	11 0 0
„ under 3in.	11 15 0‡	11 0 0
Flats, 5in. and under	11 15 0‡	11 0 0
Plates, ¾in. (basis)	10 10 6	10 2 6
„ ⅞in.	10 15 6	10 7 6
„ 1in.	11 0 6	10 12 6
„ 1⅛in.	11 5 6	10 17 6
Un. ⅞in. to and incl. 6 lb. per sq. ft. (8-G.)	11 12 6	12 10 0
Boiler Plates, ¾in.	11 0 6	11 12 6
SOUTH WALES AREA—	£ s. d.	£ s. d.
Angles	10 8 0	10 0 0
Tees	11 8 0	11 0 0
Joists	10 8 0	10 0 0
Channels	10 13 0	10 5 0
Rounds, 3in. and up	11 8 0	11 0 0
„ under 3in.	11 15 0‡	11 0 0
Flats, 5in. and under	11 15 0‡	11 0 0
Plates, ¾in. (basis)	10 13 0	10 2 6
„ ⅞in.	10 18 0	10 7 6
„ 1in.	11 3 0	10 12 6
„ 1⅛in.	11 8 0	10 17 6
Un. ⅞in. to and incl. 6 lb. per sq. ft. (8-G.)	11 12 6	12 10 0

IRELAND—F.O.Q.—	BELFAST.	REST OF IRELAND.
	£ s. d.	£ s. d.
Angles	10 13 0	10 15 6
Tees	11 13 0	11 15 6
Joists	10 13 0	10 15 6
Channels	10 18 0	11 0 6
Rounds, 3in. and up	11 13 0	11 15 6
„ under 3in.	12 0 0‡	12 2 6
Plates, ¾in. (basis)	10 15 6	10 18 0
„ ⅞in.	11 0 6	11 3 0
„ 1in.	10 5 6	11 8 0
„ 1⅛in.	11 12 6	12 10 0
Un. ⅞in. to ¼in. incl.	11 12 6	11 12 6

‡ *Rounds and Flats tested quality; untested, 6s. less.*

OTHER STEEL MATERIALS

	Home.	Export, f.o.b.
Sheets—	£ s. d.	£ s. d.
11-G. and 12-G., d/d 13 15 0 / 13-G., d/d 14 2 6	11-G. to 14-G.	12 10 0
14-G. to 20 G., d/d	14 10 0	15-G. to 20-G. 12 15 0
21-G. to 24-G., d/d	14 15 0	21-G. to 24-G. 13 0 0
25-G. and 26-G., d/d	15 10 0	25 and 26-G. 13 15 0

South Africa, Rhodesia, Nyasaland, £14; Canada, £14 12s. 6d., f.o.b. basis. Irish Free State, £14 15s., f.o.q., 4-ton lots.

The above home trade sheet prices are for 4-ton lots and over; 2-ton to 4-ton lots, 7s. 6d. per ton extra; and under 2-ton lots to 10-cwt., £2 per ton extra.

Galvanised Corrugated Sheets, basis 24-G.—

Home.	£ s. d.
4-ton lots and up	17 5 0
2-ton to 4-ton lots	17 12 6
Under 2 tons	18 17 6

Export: India, £15 15s. c.i.f.; Irish Free State, £17 5s., f.o.q.; General, £15 15s., f.o.b., 24-G. basis.

TIN-PLATES—
20 by 14 basis, f.o.b., Bristol Channel Ports, 20s. 3d.
Tin-plate Bars, d/d Welsh Works, £7 5s.

BILLETS—100-ton lots and over, 35 to 100 tons, 5s. extra; less than 35 tons, 10s. extra.

	£ s. d
Soft (up to 0·25% C.), untested	7 7 6
„ „ tested	7 12 6
Basic (0·33% to 0·41% C.)	7 17 6
„ Medium (0·42 to 0·60% C.)	8 10 0
„ Hard (0·61% to 0·85% C.)	9 0 0
„ „ (0·88% to 0·99% C.)	9 10 0
„ „ (over 0·99% C.)	10 0 0
Rails, Heavy, 500-ton lots, f.o.t.	9 10 0
„ Light, f.o.t.	8 10 0

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	4/9½ per lb. (nominal)	
Ferro-Tungsten	4/8 per lb. (nominal)	
Ferro-Chrome, 4 p.c. to 6 p.c. carbon	£23 15 0	7/6
„ 6 p.c. to 8 p.c.	£23 10 0	7/6
„ 8 p.c. to 10 p.c.	£23 10 0	7/6
„ Max. 2 p.c. carbon	£36 0 0	11/-
„ „ 1 p.c. carbon	£38 5 0	11/-
„ „ 0·5 p.c. carbon	£41 0 0	12/-
„ „ carbon-free	10d. per lb.	
Metallic Chromium	2/5 per lb.	
Ferro Manganese (loose), 76 p.c.	£16 15 0 home	
„ Silicon, 45 p.c. to 50 p.c.	£12 10 0 scale 5/- p.u	
„ „ 75 p.c.	£17 0 0 scale 6/- p.u	
„ Vanadium	14/- per lb.	
„ Molybdenum	4/9 per lb.; 5/- forward	
„ Titanium (carbon-free)	9d. per lb.	
Nickel (per ton)	£185 to £190 per ton	
Cobalt	8/6 to 8/9 per lb.	

NON-FERROUS METALS.

(*Official Prices, January 4th.*)

COPPER—	
Cash	£44 6 3 to £44 7 6
Three Months	£44 11 3 to £44 12 6
Electrolytic	£50 0 0 to £50 15 0
Best Selected Ingots, d/d Birmingham	£50 10 0
Sheets, Hot Rolled	£80 0 0

	Home.	Export.
Tubes, Solid Drawn (basis)	12¾d.	12¾d.
„ Brazed (basis)	12¾d.	12¾d.
BRASS—		
Ingots, 70/30, d/d Birmingham	£39 0 0	
	Home.	Export.
Tubes, Solid Drawn, 2/1 Alloy	11¾d.	11¾d.
„ Brazed	13¼d.	13¼d.

TIN—	
Cash	£217 0 0 to £217 5 0
Three Months	£218 0 0 to £218 5 0
SPELTER—	
Cash	£13 15 0 to £13 16 3
Three Months	£13 18 9 to £14 0 0
LEAD—	
Cash	£14 16 3 to £14 17 6
Three Months	£15 1 3 to £15 2 6
Aluminium Ingots (British)	£94 (net)

FUELS.

SCOTLAND

	Export.
LANARKSHIRE—	
(f.o.b. Grangemouth)—	
Navigation Unscreened	18/6
Hamilton Ell	18/6
Splints	19/- to 19/6
AYRSHIRE—	
(f.o.b. Ports)—Steam	16/6 to 17/-
FIFESHIRE—	
(f.o.b. Methil or Burntisland)—	
Prime Steam	17/6 to 18/-
Unscreened Navigation	18/- to 18/6
LOTHIANS—	
(f.o.b. Leith)—Hartley Prime	17/6
Secondary Steam	16/9

ENGLAND

SOUTH YORKSHIRE, HULL—	
B.S.Y. Hards	20/6 to 21/-
Steam Screened	17/6 to 18/-
NORTHUMBERLAND, NEWCASTLE—	
Blyth Best	18/6
„ Second	17/-
„ Best Small	17/-
Unscreened	17/- to 18/-
DURHAM—	
Best Gas	19/4½
Foundry Coke	27/- to 28/-

SOUTH WALES

CARDIFF—	
Steam Coals:	
Best Admiralty Large	24/-
Best Seconds	23/6 to 24/-
Best Dry Large	23/- to 23/6
Ordinaries	23/-
Bunker Smalls	16/- to 17/6
Cargo Smalls	15/6 to 16/-
Dry Nuts	27/6 to 28/-
Foundry Coke	31/- to 42/6
Furnace Coke	29/-
Patent Fuel	25/6
SWANSEA—	
Anthracite Coals:	
Best Large	38/- to 41/-
Machine-made Cobbles	41/- to 45/6
Nuts	40/- to 45/-
Beans	33/- to 38/6
Peas	26/- to 30/-
Rubbly Culm	15/- to 16/-
Steam Coals:	
Large Ordinary	22/6 to 24/6

FUEL OIL.

Inland consumption: contracts in bulk.

Exclusive of Government tax of 1d. per gallon: and 9d. per gallon on oil for road vehicles.

Ex Ocean Installation.	Per Gallon.
Furnace Oil (0·950 gravity)	3¾d.
Diesel Oil	4¼d.

French Engineering Notes

(From our own Correspondent in Paris).

A Changed Industrial Situation

THE recent collapse of the syndicalist domination over employers that had lasted 2½ years and ended with the defeat of the C.G.T. in its attempt to organise a general twenty-four hours' strike against the Government's decrees, has entirely changed the industrial situation. The cloud has lifted and confidence is restored alike among employers and workers, who enter the New Year under hopeful conditions with the prospect of a steady trade revival. The C.G.T. was powerful so long as it was recognised by the Popular Front Government as the sole official representative of the working community. That Government has disappeared and the new Government, which set itself the task of rebuilding the country's financial and economic structure on a normal basis, was obliged at the outset to demolish the authority of the Labour Confederation. As was to be expected, the great majority of workers refused to obey its strike orders. They had reason to be dissatisfied with the political action of the C.G.T. While rates of wages were increased there was less work, and the real value of the higher wages for forty hours tended to lessen with the steady advance in commodity prices. What they had gained was a statute that ensured for them fair and generous treatment from employers by means of collective contracts that specified the obligations both of the men and their employers and restored to the latter their authority in the conduct and management of their works. The men are conscious that they are being fairly treated, and when the Reynaud three years' plan, which has been sanctioned by Parliament, increased the working week to forty-eight hours when required to deal with pressure of work, with moderate overtime pay for hours exceeding the forty which are maintained in principle, the idea of more work and more pay appealed to most of them. The New Year has therefore begun with every prospect of a revival of industrial activity. Now that confidence has been restored and capital is returning to the country, many municipalities and other public bodies are putting in hand undertakings that have long been in abeyance. So far as it affects private industry, this revival of confidence is subjected to restraining influences arising out of additional heavy financial burdens imposed upon all classes of the community and of the disturbing international situation. Notwithstanding these influences, there is already evidence to show that a good start has been made. Increased working hours have given more freedom to employers in developing business, and the full forty-eight hours are being worked in nearly all branches of the engineering industry, particularly to meet the needs of an accelerated armament production.

Public Works

Proposals to construct the Canal des Deux Mers between the Atlantic and the Mediterranean have passed through many and varied phases since they were first advanced in the earlier part of last century. Originally, the canal was to have been of a purely strategical character and during the following decades plans were repeatedly altered with a view to its use by merchant shipping traffic, for which reason the section was reduced in order to meet objections to the canal on the grounds of prohibitive cost. The latest plans which have been prepared during the past ten years have eliminated many of the former technical difficulties. The Mediterranean terminus of the canal will be the little town of La Nouvelle to the south of Narbonne, while at the Bordeaux end the Garonne will be utilised. The total length will be 248 miles and the width 492ft. Few schemes have been more persistently criticised on economic grounds than the Canal des Deux Mers, and its construction appeared very remote until it was announced last week that an arrangement had been made with French, British, and Dutch banks to advance a total of 90 million pounds over four or five years to carry out the work. Most of the money will be supplied, it is said, by the Dutch financiers. Another work that will be put in hand immediately is the completion of the Bussang tunnel through the Vosges between Saint-Maurice and Wesserling, which will shorten the Nancy-Mulhouse line by 32½ miles. There are other considerations besides shortening the journey that favour the construction. This tunnel, the longest in France, will have a length of 9060 yards, more than one-half of which was completed in 1935 when difficulties arose through encountering hard rock, and then a flooding that caused a suspension of work until more funds could be procured. The Government could then do nothing, but in the recent decrees that suspended Government expenditure on public works it was announced that something would be done to permit of a resumption of work on the Bussang tunnel. This decision has now been officially confirmed by the inclusion of the tunnel in the works for national defence that are not comprised in the retrenchment plan.

Free Zones for Sea Ports.

The demands which Maritime Chambers of Commerce have long been making for the creation of free zones at leading ports have been granted in principle by a decree declaring that such zones may be authorised under conditions that differ from those existing at foreign ports. Difficulties that have delayed the creation of zones at ports with the object of facilitating export trade by working up imported materials in areas outside the Customs limit are mainly fiscal, and as a precaution against works being established with the object of avoiding payment of import duties, it is provided that industries can only be carried on when they are new to France or have disappeared. The object of instituting free zones is to utilise them for international markets where all kinds of goods and materials can be imported duty free and will only be subjected to the payment of duties when they pass the Customs barriers. These international markets are intended to provide facilities for an exchange of goods, and importers will be able to store and demonstrate their goods and machines in the zones and only pay duty when they are delivered to customers. The principle of the zones is welcomed by the Maritime Chambers of Commerce, which, however, insist that more tolerance should be allowed for the establishment of works and factories.

British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

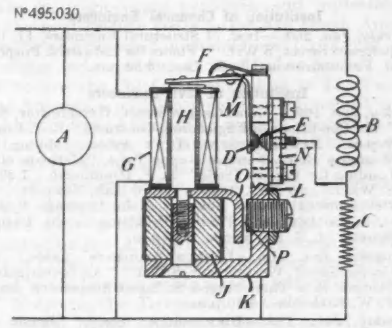
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

DYNAMOS AND MOTORS

495,030. May 4th, 1937.—DYNAMO REGULATORS, Joseph Lucas, Ltd., of Great King Street, Birmingham, 19, and John Andrew Laird, of the same address.

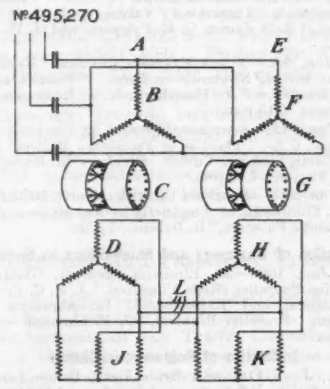
This invention applies to dynamo regulators of the type adapted to control a resistance in series with the field winding of the dynamo through the agency of an electro-magnet which is responsive to the output voltage and/or current. The dynamo armature is indicated by A and the field winding by B. In series with the field winding is a resistance C controlled in the usual way by separable contacts D E, the contact D being movable, and the contact E fixed. The movable contact is carried by the armature F of the electro-magnet G, which is provided with a voltage winding, and if desired with a current winding. At one end of the core H of the electro-magnet is a cylindrical or other permanent magnet J, the polarity of which opposes that of the electro-magnet when the latter is excited. The end of the permanent magnet remote from the core H is mounted on an iron base K on which is formed a bar L extending alongside the two magnets G J. The armature F of the electro-magnet G is in the form of a bell-crank lever, and is pivotally connected to the outer end of the bar L by a blade spring M. One arm of the bell-crank lever extends over the free end of the electro-magnet core H and the other arm carries the movable



contact D, which co-operates with the fixed contact E, the latter being adjustably mounted on a supporting piece N secured to but insulated from the bar L. Between the adjacent ends of the core H and permanent magnet J is another iron member O, which is shaped to form between one of its ends and the adjacent side of the bar L an air gap P to provide a shunt path for the magnetic fluxes. Any convenient means, such as a screw-threaded piece on the bar L, may be provided for adjusting the width of the air gap. When the electro-magnet G is not excited the contacts D E are held together by the action of the flux of the permanent magnet J passing through the core H, the armature F, side bar L, and base K. When the electro-magnet G is excited, its magneto-motive force opposes that of the permanent magnet and tends to drive the flux of the latter across the shunt path P, thus weakening the action on the armature F. When the forces exerted by the two magnets are balanced or nearly balanced, the spring M, acting on the armature F, causes the contacts D E to be separated and the field resistance C to be thereby brought into action. At this stage the regulator acts in the usual manner, vibratory motion of the armature F due to variation in the excitation of the electro-magnet G causing the resistance C to be varied in the appropriate manner for regulating the dynamo output.—*November 4th*, 1938.

495,270. July 27th, 1937.—INDUCTION MOTOR EQUIPMENTS, Albert Walsh, of 106, Cecil Road, Hale, Chester; Norman Richard Dawson Gurney, of 262, Withington Road, Chorlton-cum-Hardy, Manchester; and Metropolitan-Vickers Electrical Company, Ltd., Kingsway, London, W.C.2.

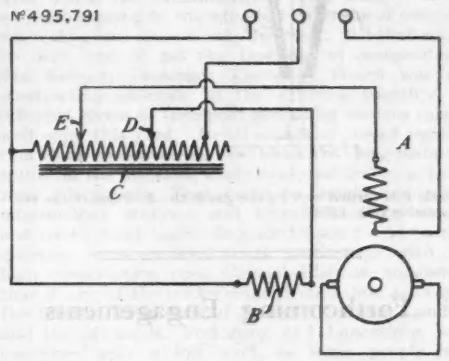
The main object of this invention is to provide an arrangement whereby a pair of induction motor equipments when driving substantially independent loads may be maintained at the same speeds or at speeds which bear a predetermined relationship. The equipments both have three-phase stator windings fed from the same supply system, and machine A



has a primary stator winding B, a double rotor C, and a tertiary winding D, whilst the machine E has a primary winding F, a rotor G, and a tertiary winding H. The rotor windings so designed that the tertiary induced voltages are the same for D and H when the overall percentage slips are the same for the two equipments. Resistances J K are connected across the tertiary windings, and corresponding phases of the two tertiary windings are interconnected by connections L. Normally each tertiary winding causes a polyphase current to flow through its corresponding resistance, and provided the percentage slip is the same for each machine and the induced voltages remain in phase for the interconnected phases of the two tertiary windings, no circulating current will flow through the connections L between the two tertiary windings. If, however, phase differences arise due to an incipient divergence of slips circulating current will flow through the connections L, and this current flowing through the stators will produce torques on the rotors tending to restore the proper relationship of their angular positions.—*November 10th*, 1938.

495,791. May 20th, 1937.—ELECTRIC MOTORS, Crocker-Wheeler Electric Manufacturing Company, Ampere, State of New Jersey, U.S.A.

The A.C. motor described in this specification may be generally similar in construction to a D.C. shunt motor except that the field is laminated as well as the armature. The field ring carries two stator windings placed as shown 90 electrical degrees apart. One of these windings A serves as the field winding for the motor, and the other, B, as a main or transformer winding for the armature. It is therefore placed as usual with its axis coincident with the axis of the winding on the armature. The armature is provided as shown with two brushes in line with the axis of the main winding B, and these brushes are short circuited and the working electromotive force is induced in the armature by transformer action from the main stator winding B. An auto-transformer C is connected across one phase of the three-

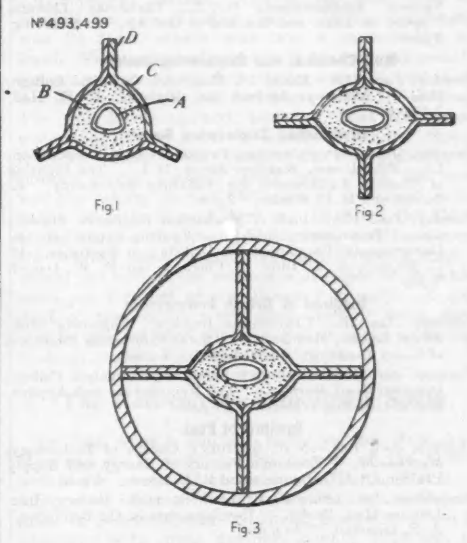


phase power supply source. By providing this auto-transformer with taps and an adjustable contact D, any desired electromotive force may be applied to the main stator winding B as a convenient means to adjust the speed of the motor by controlling the electromotive force induced in the short-circuited armature. The auto-transformer serves as a convenient means of adjusting the phase relation between the field winding A and the current in the armature or working current by connecting the field winding A between a tap E on the transformer C and the third line of the three-phase system. By moving this adjustable connection E up and down along the transformer winding, the phase angle of the field of the motor may be adjusted exactly to coincide with that of the actual working current in the armature and, therefore, the torque of the motor is made a maximum for any given current in the armature.—*November 21st*, 1938.

LIGHTING AND HEATING

493,499. March 26th, 1938.—TUBULAR ELECTRIC RESISTANCE HEATING ELEMENTS, Christian Bergh Backer, of 1, Park Farm Road, Bromley, Kent.

Various forms of tubular heating elements constructed in accordance with the invention are illustrated. A coiled resistance wire A is embedded in insulating material B composed for example, of magnesium oxide, which is enclosed by a tubular casing C. In the form illustrated in Fig. 1 the casing is made



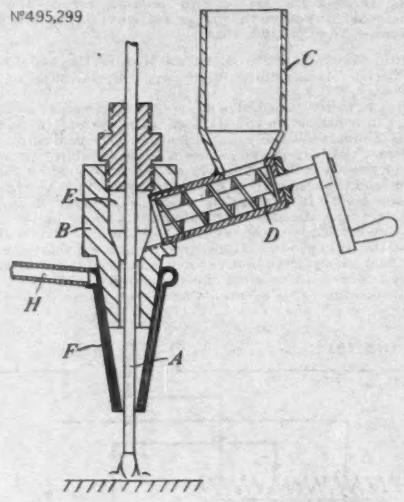
from three sheets C of heat-resisting metal or alloy, which are bent into the shape shown, the parts of the sheets which form the projecting ribs D being connected by spot or seam welding. In the form shown in Fig. 2 four sheets of metal are employed instead of three sheets, and there are then four projecting ribs. The tubular element in the case of Fig. 3 may be enclosed in an outer tube, in which case the projecting ribs serve to hold the element in position.—*October 10th*, 1938.

WELDING

495,299. May 10th, 1938.—ELECTRIC WELDING, The British Thomson-Houston Company, Ltd., Crown House, London, W.C.2.

The invention concerns an electric arc welding process in which bare welding wire is used. The welding wire A, which may be moved by feed rollers, is surrounded in the neighbourhood of the arc by a head B acting as an injector. By means of a conveyor consisting of a hopper C and a screw D rotatably mounted in a cylinder, powdered material is brought into the space E. By the feed of the welding wire A and by its own weight the additional material moves towards the arc. Below the hollow space E is fixed a nozzle F connected with the gas conduit H. The screw D can be moved by hand by a crank handle, or by means of a variable-speed motor. The powder

or paste material conveyed by the screw into the hollow space E is moved downwards by the feed of the electrode A and by its weight, and owing to the protective gas issuing from the



nozzle F is carried over by the gas in the direction of the arc.—*November 10th*, 1938.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Air Raid Protection Institute

Tuesday, Jan. 10th.—Royal Soc. of Arts, John Street, Adelphi, W.C.2. "A.R.P. in a Metropolitan Borough," Dr. R. H. R. Tee. 8 p.m.

Bradford Engineering Society

Monday, Jan. 9th.—Technical College, Bradford. Film, "The Inside Story" (Vacuum Oil Company Ltd.). 7.30 p.m.

Chartered Surveyors' Institution

Monday, Jan. 9th.—12, Great George Street, Westminster, S.W.1. "The Coal Act, 1938 (Part I): Unification of Coal Mining Royalties," A. R. Thomlinson. 6.30 p.m.

Diesel Engine Users Association

Wednesday, Jan. 11th.—Caxton Hall Westminster, S.W.1. Report on Heavy-Oil Engine Working Costs, 1937–38. 4.45 p.m.

Engineering Public Relations Committee

To-day, Jan. 6th.—Inst. of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2. Christmas Lecture. "Speed on Land and Sea and in the Air," J. S. Irving. 3 p.m.

Hull Chemical and Engineering Society

Tuesday, Jan. 17th.—Room 51, Municipal Technical College, Hull. "Alchemy, Ancient and Modern," E. H. Hall. 7.45 p.m.

Illuminating Engineering Society

Tuesday, Jan. 10th.—Gaumont-British Picture Corporation, Ltd., Film House, Wardour Street, W.1. "The Lighting of Cinema Auditoriums for Visibility and Safety," E. Stroud and H. C. Weston. 7 p.m.

Tuesday, Jan. 17th.—Inst. of Mechanical Engineers, Storey's Gate, Westminster, S.W.1. "Fourth Report of the Departmental Committee on Lighting in Factories," H. C. Weston, A. E. Iliffe, G. Chelioti, and R. W. Daniel. 7 p.m.

Institute of British Foundrymen

Saturday, Jan. 7th.—LANCASHIRE BRANCH: Engineers' Club, Albert Square, Manchester. "Some Interesting Examples of Loam Moulding," R. D. Lawrie. 4 p.m.

Tuesday, Jan. 10th.—BURNLEY SECTION: Municipal College, Ormerod Road, Burnley. "The Manufacture and Application of Grinding Wheels." 7.30 p.m.

Institute of Fuel

Tuesday, Jan. 10th.—N.W. SECTION: College of Technology, Manchester. "Economic Factors of Energy and Supply Problems," J. G. Bennett and R. L. Brown. 6 p.m.

Wednesday, Jan. 18th.—E. MIDLAND SECTION: Railway Inst. Lecture Hall, Derby. "Developments in Oil Refineries," A. E. Dunstan. 7.30 p.m.

Tuesday, Jan. 24th.—Geological Society's Rooms, Burlington House, Piccadilly, W.1. "The Use of Anthracite Duff for Steam Generation," E. B. Johnson. 6 p.m.

Institute of Marine Engineers

Tuesday, Jan. 10th.—85–88, The Minories, Tower Hill, E.C.3. "Some Recent Diesel Installations and their Characteristics," C. C. Pounder. 6 p.m.

Thursday, Jan. 19th.—JUNIOR SECTION: 85–88, The Minories' Tower Hill, E.C.3. Film lecture, "The Boulder Dam," C. M. Roberts. 7 p.m.

Institute of Metals

Tuesday, Jan. 10th.—N.E. COAST LOCAL SECTION: Electrical Engineering Lecture Theatre, King's College, Newcastle-upon-Tyne. "Mechanisation in the Foundry." 7.30 p.m.

Thursday, Jan. 12th.—LONDON LOCAL SECTION: S.M.M.T., Hobart House, Wilton Street, S.W.1. "The Tarnishing of Silver and Silver Alloys and its Prevention," and "Oxidation-Resistance in Copper Alloys," L. E. Price and G. J. Thomas. 7.30 p.m.

Monday, Jan. 16th.—SCOTTISH LOCAL SECTION: 39, Elmbank Crescent, Glasgow. "The Development of Corrosion-resisting Aluminium Alloys," G. W. Lacey. 7.30 p.m.

Tuesday, Jan. 17th.—BIRMINGHAM LOCAL SECTION: James Watt Memorial Inst., Great Charles Street, Birmingham. "Practice in Mechanical Testing," V. E. Green. 7 p.m.

Institute of Transport

Monday, Jan. 9th.—Inst. of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2. "Passenger Transport by Road in relation to Railway Services," Colonel A. S. Redman. 5.30 p.m.

Tuesday, Jan. 17th.—Inst. of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2. "The Railways and the Trader," A. Hastie. 6 p.m.

Institution of Automobile Engineers

Monday, Jan. 9th.—DERBY CENTRE: Technical College, Derby. "Unification of Body and Chassis Frame," W. Swallow. 7.30 p.m.

Tuesday, Jan. 10th.—BIRMINGHAM CENTRE: James Watt Memorial Inst., Great Charles Street, Birmingham. "Plastics in the Motor Car Industry," L. J. B. Forbes. 7.30 p.m. COVENTRY CENTRE: King's Head Hotel, Coventry. "Unification of Body and Chassis Frame," W. Swallow. 7.30 p.m.

Wednesday, Jan. 11th.—MANCHESTER GRADUATES: Visit to printing works of *Daily Express*, Great Ancoats Street, Manchester. 7.45 p.m. PRESTON CENTRE: Victoria and Station Hotel, Preston. "Automobile Construction in Terms of Light Alloys," L. H. Pomeroy.

Thursday, Jan. 12th.—BRISTOL CENTRE: Merchant Venturers' Technical College, Bristol. "Supercharging of Compression-ignition Engines," J. H. Pitchford. 7 p.m.

Tuesday, Jan. 17th.—LONDON GRADUATES: 12, Hobart Place, S.W.1. "Some Notes on Leaf Spring Design," P. Aldworth. 7.25 p.m. LUTON CENTRE: George Hotel, Luton. "Unification of Body and Chassis-Frame," W. Swallow. 7.30 p.m.

Wednesday, Jan. 18th.—LEEDS CENTRE: Metropole Hotel, Leeds. "The Use of Gas as a Fuel for Motor Vehicles," S. C. Clarke. 7.15 p.m.

Monday, Jan. 23rd.—GLASGOW CENTRE: 39, Elmbank Crescent, Glasgow. "Factory Experimental Work," A. G. Booth. 7.45 p.m.

Tuesday, Jan. 24th.—BIRMINGHAM CENTRE: James Watt Memorial Inst., Great Charles Street, Birmingham. "Battery-driven Electric Vehicles," R. Tubb. 7.30 p.m.

Institution of Chemical Engineers

Thursday, Jan. 26th.—Inst. of Structural Engineers, 11, Upper Belgrave Street, S.W.1. "Floors for Industrial Purposes," R. Fitzmaurice and F. M. Lea. 6.30 p.m.

Institution of Civil Engineers

Tuesday, Jan. 10th.—Great George Street, Westminster, S.W.1. "The Conditions of Engineering Contracts," E. J. Rimmer, 6 p.m. NEWCASTLE-UPON-TYNE ASSOC.: Mining Inst., Westgate Road, Newcastle-upon-Tyne, "Methods of Coal Loading for Export Trade," R. F. Hindmarsh. 7.30 p.m. S. WALES AND MON. ASSOC.: Town Hall, Newport. "The Development of the Newport Main Drainage System," C. G. Cobbett, and "Some Problems in the Design of Sewers," J. R. Daymond. 6.45 p.m.

Wednesday, Jan. 11th.—LONDON STUDENTS' ASSOC.: Great George Street, Westminster, S.W.1. "An Investigation of Stresses in a Three-hinged Stiffened Suspension Bridge," J. W. Roderick. 6.30 p.m.

Thursday, Jan. 12th.—BIRMINGHAM ASSOC.: James Watt Memorial Inst., Great Charles Street, Birmingham. "Deep Diving and Submarine Operations," Captain G. C. C. Damant. 6 p.m. BRISTOL ASSOC.: Royal Hotel, College Green, Bristol. "Some Notes on the Road Congress in Holland," H. M. Webb. 5 p.m. PORTSMOUTH ASSOC.: University College, Southampton. "The Design of Engineering Works from the Maintenance Standpoint," J. P. M. Pannell. 7.15 p.m. YORKSHIRE ASSOC.: Grand Hotel, Sheffield. Dugald Clerk Lecture, W. A. Tookey. 7.30 p.m.

Saturday, Jan. 14th.—LONDON STUDENTS' ASSOC.: Visit to extensions of the County Hall, Westminster Bridge Road, S.E.1. (afternoon).

Monday, Jan. 16th.—BRISTOL ASSOC.: Royal Hotel, College Green, Bristol. "Southampton Docks," M. G. J. McHaffie. 5 p.m. N. IRELAND ASSOC.: Queen's University, Belfast. "Modern Methods of Road Construction," T. R. Grigson. 6.15 p.m.

Tuesday, Jan. 17th.—Great George Street, Westminster, S.W.1. Joint meeting with British Section, Soc. des Ingénieurs Civils de France. "The Strengthening of the Austerlitz Viaduct in Paris," Monsieur Fauconnier. 6 p.m. NEWCASTLE-UPON-TYNE ASSOC.: Mining Inst., Westgate Road, Newcastle-upon-Tyne. "Mass Concrete Structures," J. A. Stephenson. 7.30 p.m.

Wednesday, Jan. 18th.—Great George Street, Westminster, S.W.1. Informal discussion on "Co-operation between the Civilian Engineer and the Military Engineer," introduced by Sir Clement Hindley and Lieut.-Colonel F. H. Budden. 6 p.m. MANCHESTER ASSOC.: Literary and Philosophical Soc., 36, George Street, Manchester. "Water Towers," E. L. Morgan. 6.45 p.m. NEWCASTLE-UPON-TYNE ASSOC.: Co-operative Society's Café, Stockton-on-Tees. "Refuse Disposal Plant at Middlesbrough," T. V. Burrows. 7 p.m.

Institution of Electrical Engineers

To-day, Jan. 6th.—METER AND INSTRUMENT SECTION: Savoy Place, Victoria Embankment, W.C.2. "Instruments Incorporating Thermionic Valves and their Characteristics," E. G. James, G. R. Polgreen, and G. W. Warren. 7 p.m.

Monday, Jan. 9th.—NORTH-EASTERN CENTRE: Newe House, Pilgrim Street, Newcastle-on-Tyne. "Plastics and Electrical Insulation," L. Hartshorn, N. J. L. Megson, and E. Rushton. 6.15 p.m.

Tuesday, Jan. 10th.—SCOTTISH CENTRE: 39, Elmbank Crescent, Glasgow, C.2. "The Use of Protective Multiple Earthing and Earth-Leakage Circuit Breakers in Rural Areas," H. G. Taylor. 7.30 p.m.

Tuesday, Jan. 24th.—SCOTTISH CENTRE: North British Station Hotel, Edinburgh. "Electricity in Coal Mines: A Retrospect and a Forecast," R. Nelson. 7 p.m.

Institution of Engineers and Shipbuilders in Scotland

Tuesday, Jan. 10th.—39, Elmbank Crescent, Glasgow, C.2. "Marine Propeller Blade Vibration," J. F. C. Conn; and "Statistical and Experimental Investigations on the 'Singing' Propeller Problem," J. F. Shannon and R. N. Arnold.

Institution of Engineers-in-Charge

Wednesday, Jan. 11th.—St. Bride Inst., Bride Lane, Fleet Street, E.C.4. "Selection and Purchase of Fuel for Steam-raising Purposes," H. L. Pirie. 7.30 p.m.

Institution of Locomotive Engineers

Wednesday, Jan. 25th.—Inst. of Mechanical Engineers, Storey's Gate, Westminster, S.W.1. "A Diesel Train Set with Multiple Axle Drives," H. F. Haworth and T. Hornbuckle. 6 p.m.

Institution of Mechanical Engineers

To-day, Jan. 6th.—Storey's Gate, Westminster, S.W.1. Thomas Lowe Gray Lecture. "Some of the Aspects and Problems of the Development of High-speed Craft and its Machinery," H. Scott-Paine. 6 p.m.

Monday, Jan. 9th.—NORTH-EASTERN BRANCH: Mining Institute, Newcastle-upon-Tyne. "Sir Charles Parsons and Marine Propulsion," S. S. Cook. 6.30 p.m.

Thursday, Jan. 12th.—NORTH-WESTERN BRANCH: Engineers' Club, Albert Square, Manchester. "Sir Charles Parsons and Marine Propulsion," S. S. Cook. 7.15 p.m. SCOTTISH BRANCH: Rankine Hall, 39, Rankine Street, Glasgow. "Some of the Aspects and Problems of the Development of High-speed Craft and its Machinery," H. Scott-Paine. 7.30 p.m. YORKSHIRE BRANCH: Hotel Metropole, Leeds. "Cast Iron," J. E. Hurst. 7.30 p.m.

Friday, Jan. 13th.—Storey's Gate, Westminster, S.W.1. "The Safety Provisions of the New Factory Act," G. Stephenson Taylor. 6.30 p.m.

Wednesday, Jan. 18th.—NORTH-WESTERN BRANCH: 9, The Temple, Dale Street, Liverpool. "Some Aspects and Problems of the Development of High-speed Craft and its Machinery," H. Scott-Paine. 6.30 p.m.

Thursday, Jan. 19th.—MIDLAND BRANCH: James Watt Memorial Inst., Great Charles Street, Birmingham. Annual meeting. Exhibition of films. 6.20 p.m. SOUTHERN BRANCH: Municipal College, Portsmouth. "Sir Charles Parsons and Marine Propulsion," S. S. Cook. WESTERN BRANCH: Merchant Venturers' Technical College, Bristol. "Mechanical Vibrations," C. E. Inglis. 7 p.m.

Institution of Sanitary Engineers

To-day, Jan. 6th.—Caxton Hall, Westminster, S.W.1. Presidential Address, D. M. Watson. 6.30 p.m.

Institution of Structural Engineers

Thursday, Jan. 12th.—11, Upper Belgrave Street, S.W.1. "Masonry Construction," S. B. Hamilton. 6.30 p.m.

Iron and Steel Institute

Saturday, Jan. 14th.—Technical College, Newport, Mon. "The Basic Open-hearth Modern Plant and Practice," J. A. Davies. 6.30 p.m.

Keighley Association of Engineers.

Thursday, Jan. 12th.—Victoria Hall, Keighley. "Electric Lamps and their Developments," J. W. Howell. 7.30 p.m.

Manchester Association of Engineers

Friday, Jan. 13th.—Engineers' Club, Albert Square, Manchester. "Trends in Heavy Machine Tool Design and Operation," J. H. Rivers. 7.15 p.m.

North-East Coast Institution of Engineers and Shipbuilders

To-day, Jan. 6th.—Mining Inst., Newcastle-upon-Tyne. Films on "Cavitation," "Air Flow," "The National Physical Laboratory," "Bakelite," &c. 6 p.m.

Railway Club

Thursday, Jan. 12th.—Royal Scottish Corporation Hall, Fetter Lane, E.C.4. "The Taff Vale Railway," D. S. Barrie. 7.30 p.m.

Royal Aeronautical Society

Thursday, Jan. 19th.—Inst. of Mechanical Engineers, Storey's Gate, Westminster, S.W.1. "Some Corrosion Problems Relating to Modern Aircraft," A. J. Sidery and J. W. W. Willstrop. 6.30 p.m.

Royal Institution of Great Britain

Saturday, Jan. 7th.—21, Albemarle Street, W.1. "Elements: Old and New," Prof. J. Kendall. 3 p.m.

Tuesday, Jan. 10th.—21, Albemarle Street, W.1. "Some Young American Chemists," Prof. J. Kendall. 3 p.m.

Royal Society of Arts

Wednesday, Jan. 18th.—John Street, Adelphi, W.C.2. "Recent Progress in Television," H. L. Kirke. 8.15 p.m.

Sheffield Metallurgical Association

Tuesday, Jan. 10th.—198, West Street, Sheffield. Annual general meeting. 7.30 p.m.

Society of Glass Technology

Tuesday, Jan. 10th.—Trocadero Restaurant, London, W.1. Annual dinner and dance. 7 p.m.

Wolverhampton and District Engineering Society

Monday, Jan. 9th.—Victoria Hotel, Wolverhampton. "Highway Bridges," H. E. Brooke-Bradley. 7.30 p.m.

CALENDARS, DIARIES, &c.

ASHWELL AND NESBIT, Ltd., Barkly Road, Leicester.—Wall calendar with daily tear-off sheets.

ASSOCIATED EQUIPMENT COMPANY, Ltd., Southall, Middx.—Pictorial wall calendar.

BRISTOL AEROPLANE COMPANY, Ltd., Filton House, Bristol.—Memorandum book and diary containing useful data and general information, and wall calendar.

BRITISH JEFFREY-DIAMOND, LTD., Wakefield.—Wall calendars.

BRUSH ELECTRICAL ENGINEERING COMPANY, Ltd., Falcon Works, Loughborough.—Pocket diary.

COUNTY OF LONDON ELECTRIC SUPPLY COMPANY, Ltd., 46–47, New Broad Street, E.C.2.—Humorous wall calendar.

CRAVEN BROTHERS (MANCHESTER), Ltd., Reddish, Stockport.—Wall calendar with monthly sheets showing past, present, and next month.

D. GILSON AND CO., Ltd., Billet Works, Walthamstow, E.17.—Wall calendar.

G. A. HARVEY AND CO. (LONDON), Ltd., Woolwich Road, London, S.E.1.—Pocket book and diary.

IMPERIAL CHEMICAL INDUSTRIES, Ltd., Millbank, S.W.1.—Pocket diary.

WM. JESSOP AND SONS, Ltd., Brightside Works, Sheffield.—Combined diary and pocket reference book.

J. E. RAISTRICK, Ltd., Reliance Works, Park Royal Road, London, N.W.10.—Wall calendar.

J. SAMUEL WHITE AND CO., Ltd., Cowes, Isle of Wight.—Wall calendar.

STAVELEY COAL AND IRON COMPANY, Ltd., near Chesterfield.—Combined diary and wallet.

STOTHERT AND PITT, Ltd., Bath.—Desk memorandum pad.

S. S. STOTT, Ltd., Haslingden, Rossendale, Lancs.—Wall calendar with daily tear-off sheets.

JOHN TULLIS AND SON, Ltd., St. Ann's Works, Glasgow, S.E.—Desk memorandum pad.

EDWARD WOOD AND CO., Ltd., Ocean Ironworks, Trafford Park, Manchester.—Pocket diary.

EDWARD WOOD AND CO., Ltd., Ocean Ironworks, Manchester, 17.—Wall calendar with daily tear-off sheets.

A Seven-Day Journal

A Proposed New Strip Mill

IN a circular which has been issued to the shareholders of John Summers and Sons, Ltd., calling an extraordinary general meeting to consider increasing the capital and the adoption of new articles of association, the installation of a new hot and cold strip mill is foreshadowed. The directors state that for the past few years they have been giving consideration to the advantages of constructing a new hot and cold strip mill of the American type at the company's Shotton works. Details of the plan by which the new capital is to be raised are set forth in the circular. Such capital will defray the cost of the new mill and improvements and extensions to the existing plant. With a view to further rationalisation within the steel industry the shares subscribed through the medium of the Bankers Industrial Development Company will be available for a maximum period of seven years from the passing of the shareholders' resolutions for purchase by the United Steel Companies, Ltd., upon terms which will ensure a reimbursement of the capital invested, with interest, but without any capital profit. Voting rights will be exercised in accordance with the directions of a Committee consisting of the Governor of the Bank of England, who will be the Chairman; the Deputy Governor of the Bank of England, the chairman of John Summers and Sons, Ltd., and the chairman of United Steel Companies, Ltd. Arrangements have been made for two of the directors of the United Steel Companies, Ltd., to join the board of the company and for one director of John Summers and Sons, Ltd., to join the board of the United Steel Companies, Ltd.

Inst. C.E. Road Engineering Section

THE Council of the Institution of Civil Engineers has approved the formation of a Road Engineering Section, which will include within its scope all matters appertaining to the study of road engineering, relating to planning, construction and research, and including highway bridges. The new section is to be administered by a committee, which will consist of a chairman and eight other members, five of whom, including the chairman, are to be appointed by the Council, the remainder being elected by ballot at a meeting of the section. The activities of the section will include the holding of one ordinary meeting of the Institution, presided over by the President, which will be devoted to a paper selected by the Section Committee, and approved by the Council on the recommendation of the Publications and Library Committee. The holding of such number of sectional meetings as may be determined by the Section Committee, the choice of papers and of the subjects for informal discussion for such meetings will be in the hands of the Section Committee, subject to the approval of the Council. The Section Committee will also deal, subject to the approval of the Council, with the arranging of a summer or autumn meeting, should such be thought desirable, at which papers may be read and discussed and visits to works organised. The inaugural meeting of the Section is to be held at the Institution on Wednesday, February 8th, at 6 p.m. A copy of the rules of the Section can be obtained from the Secretary, and a form for members who may wish to register their names for the purpose of receiving all notices, advance summaries of papers, and other relevant matter is being sent to all members of the Institution resident in the British Isles. It is announced that no extra subscription will be required for members who may decide to join the new Road Engineering Section.

The "Coronation Scot" Tour

IN connection with the departure of the "Coronation Scot" for an exhibition tour in the United States, the London, Midland and Scottish Railway Company held a farewell ceremony to the crew and the train at Euston Station on Monday, January 9th. The train consists of the streamlined locomotive "Coronation" and eight coaches and will be shipped from Southampton Docks on or about January 20th. The tour will begin at Baltimore on March 21st, and the train will be on show at thirty-eight American cities. After covering over 3000 miles it will conclude its tour on April 14th, when it will be prepared for exhibition at the World's Fair, New York, from April 30th to October 31st. The train, which has been designed by Mr. W. A. Stanier, incorporates new schemes of colour decoration, upholstery, and lighting prepared by Mr. Brian O'Rorke. An important departure is the construction of the train in articulated two-coach units, each coach of which weighs 30 tons. In their order from the locomotive the coaches are:—Corridor first-class brake, corridor first class, corridor first-class lounge with cocktail bar, first-class diner, kitchen car, third-class diner, first-class sleeping car, and club saloon, giving a total seating accommodation for 173 passengers and having a total weight of 262 tons 10 cwt. The coaches are insulated against noise and have controllable oil-filtered ventilation throughout. The exterior painting embodies the standard L.M.S. colours with four gold bands running the full length of the train. The locomotive is one of a series of ten and was described in THE ENGINEER of July 16th, 1937. Its leading particulars are as follows:—Four cylinders, 16½in. diameter by 28in. stroke; boiler pressure, 250 lb. per square inch; total heating surface, 3663·5 square feet; coupled wheel diameter, 6ft. 9in.; weight in working order, 108 tons 2 cwt., and with tender 164 tons 9 cwt.; tractive effort at 85 per cent. boiler pressure, 40,000 lb.

The Late Mr. F. O'Driscoll

MANY of our readers with interests in Australia and South America will learn with regret of the death, on Friday, January 6th, after a short illness, of Mr. Florence O'Driscoll, Assoc. M. Inst. C.E., who for many years combined engineering and journalistic work. O'Driscoll was born at Mountmellick, Queen's County, Ireland, and received his education in Brisbane, Australia. He entered the engineering branch of the Queensland Railway Department with which he served thirteen years on survey and constructional work. After a visit to England he spent seven years as a special correspondent, and toured the world, writing articles on engineering problems and undertakings. For the next twenty years he lived in South America, where he was engaged in mining and oil boring work, travelling and exploring in the Higher Andes. From 1910 he was the Chief Correspondent of *The Times* in South America, a position which he relinquished in 1913 in order to devote himself to work in connection with wireless telegraphy. This work occupied his attention until 1923. In his early career he was an M.P. for South Monaghan, and a Party Whip, while in 1913 he was appointed a Royal Commissioner for the World's Fair at Chicago. During the war he was entrusted by the Admiralty with the task of converting the Crystal Palace into a training depôt for the Royal Naval Division. He was the author of a treatise on "Notes on the Treatment of Gold Ores," and he contributed many articles to the scientific journals, both in this country and in America.

The Employment Returns

ON Wednesday evening, January 4th, the Ministry of Labour announced that it was provisionally estimated that on December 12th, 1938, the number of insured persons, aged 16–64, in employment in Great Britain was approximately 12,263,000. This was 5000 more than the total for November 14th, 1938. It is estimated that there was an increase of approximately 10,000 as compared with December 13th, 1937, when, however, outdoor employment was adversely affected by bad weather. Employment improved between November 14th and December 12th in coalmining, the motor vehicle, cycle and aircraft industry, metal goods manufacture, engineering, the cotton industry, the silk and artificial silk industry, dock, harbour, &c., service, the distributive trades. On the other hand, employment declined in agriculture and horticulture, building, public works contracting, fishing, the pottery and hosiery industries, and certain food-preparing industries. At December 12th, 1938, the numbers of unemployed persons on the registers of employment exchanges in Great Britain were 1,474,019 wholly unemployed, 294,708 temporarily stopped, and 62,645 normally in casual employment, making a total of 1,831,372. This was 3269 more than the number on the registers at November 14th, 1938, and 165,965 more than at December 13th, 1937. The total on December 12th, 1938, comprised 1,384,922 men, 45,549 boys, 356,580 women, and 44,321 girls. During the four weeks ended December 19th, 1938, the number of vacant situations notified by employers to the employment exchanges and juvenile employment bureaux was 212,334, while the number filled was 182,868. Between December 21st, 1937, and December 19th, 1938, 2,616,323 vacant situations were filled, while in the period December 22nd, 1936, to December 20th, 1937, the number filled was 2,624,978.

Road and Rail Passenger Transport

IN a paper presented to the Institute of Transport on Monday, January 9th, Colonel A. S. Redman, the ex-Chairman of the Traffic Commissioners for the West Midland area, dealt with the co-ordination of passenger traffic by road and rail. In the paper the view was stressed that in the present circumstances fair competition between road and rail services could only be hoped for by the adoption of fares which would cover sufficiently the high standards of vehicle operation and employment. If these essential factors were on a satisfactory basis, should not, he said, the supply of seats be in accordance with the public demand? If the patronage of an essential rail service was insufficient to make it an economic proposition then it would have to be subsidised directly. Under present conditions, in spite of being fully loaded and even overloaded at peak times, the railways, in rendering their essential national services, provided on an average three empty seats for each one loaded. As a comprehensive service of passenger trains with only a 25 per cent. load factor must continue, it seemed likely that if the protection of the Road Traffic Acts proved insufficient, some direct subsidy might be necessary which would, he thought, force the nationalisation of the railways. With regard to further progress in co-ordinating passenger transport, such progress must of necessity be slow owing to the difficulties with which the Commissioners were faced. They were attempting to co-ordinate two forms of activity when they had control only over one. All that could be done was to get the best out of competition. The London Passenger Transport Board was an outstanding example of the drawing together of different forms of transport and other centres might well copy this plan. In all countries recent legislation had endeavoured to conserve long-distance traffic for the railways, while local road traffic services were advocated. That being so, might not some intermediate stations and branch lines be closed and feeder road traffic depended upon? As to the question of a modern trunk motorway, with its high construction cost, Colonel Redman suggested that if one of the under-utilised main line railways, the former Great Central Railway between London and the Midlands, Yorkshire, and Lancashire, was converted into a toll road, as some people had suggested, and limited to motor traffic with a uniform maximum speed, a measure of segregation of road traffic, with a consequent increase in road safety, would be achieved.

The Thames Conservancy Board

AT a meeting of the Thames Conservancy Board which took place on Monday, January 9th, Captain Jocelyn Bray, the Chairman of the Board, reviewed the effects of rain and snow in the Thames area during 1938. The banks of the river Thames and its tributaries were, he said, still intact, although, following the quick thaw of last week-end, the flow of the river, as measured at the Teddington weir, had risen to a rate of 4,500,000,000 gallons daily, which compared with a standard natural flow for January of 2,407,000,000 gallons. At the present time, he continued, there was no indication that this high rate of flow would be materially exceeded. During December, the average daily natural flow of the river was 2,450,000,000 gallons, compared with a standard figure for the month of 2,073,000,000 gallons. During the past year the rainfall in the Thames basin above Teddington was 24·25in., which was not a remarkably low level. Meteorologically the past year was remarkable for an extraordinary low spring rainfall, but in the last six months the fall had been above the average. The well levels showed, however, that the subsoil water had not yet risen to its normal height. Speaking of the tasks which awaited the Board during the present year, Captain Bray said that the chief was the taking over of 730 miles of river and tributaries as extra "main" river. In April the Board would start a five-year programme, and he assured the county and county borough councils that it would not exceed the estimates of expenditure which were put forward at the Ministry inquiry. A good deal of inspection work had already been done, and he was satisfied that the Board ought to be able to keep within the limits laid down.

The Retirement of Sir Frank Smith

IN last week's Journal note on the New Year Honours we referred to the honour of the G.B.E. which was conferred on Sir Frank Smith, F.R.S., in recognition of his services as Secretary of the Department of Scientific and Industrial Research which he has filled with great distinction since 1929 and his secretaryship of the Royal Society from which he retired a short time ago. On Friday, January 6th, it was officially announced by the Department of Scientific and Industrial Research that Sir Frank Smith has decided to relinquish his appointment as Secretary to the Committee of the Privy Council for Scientific and Industrial Research on Tuesday, January 31st. The King has been graciously pleased to approve the appointment of Professor E. V. Appleton, D.Sc., F.R.S., to succeed Sir Frank Smith. Professor Appleton, it may be remembered, is at present the Jacksonian Professor of Natural Philosophy in the University of Cambridge, and a Fellow of St. John's College, Cambridge. He will take up his new appointment on Wednesday, February 1st. We understand that Sir Frank Smith has accepted a position as adviser on research and development to the Anglo-Iranian Oil Company, and there is therefore every reason for believing that his great abilities as a scientist and organiser will not be lost.

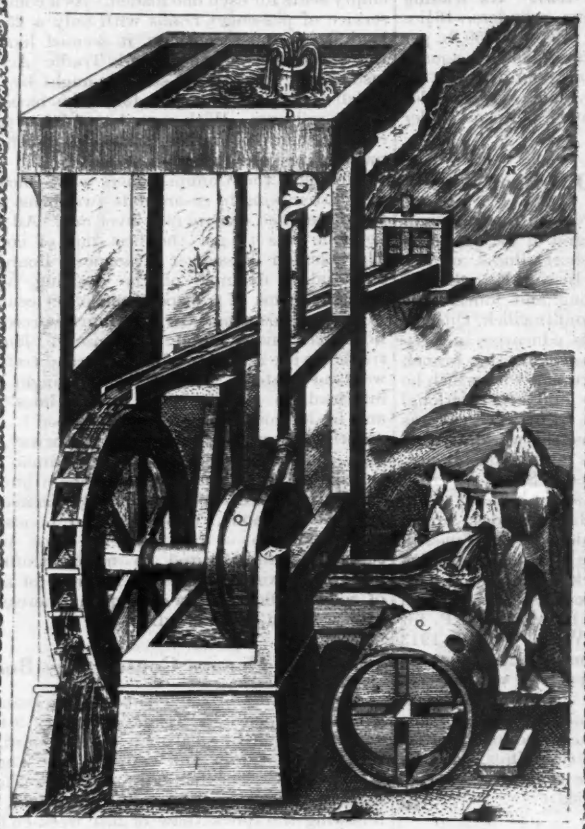
E

ANCIENT ROTARY PUMPS

(For description see opposite page)

DELL' ARTIFICIOSE MACHINE.

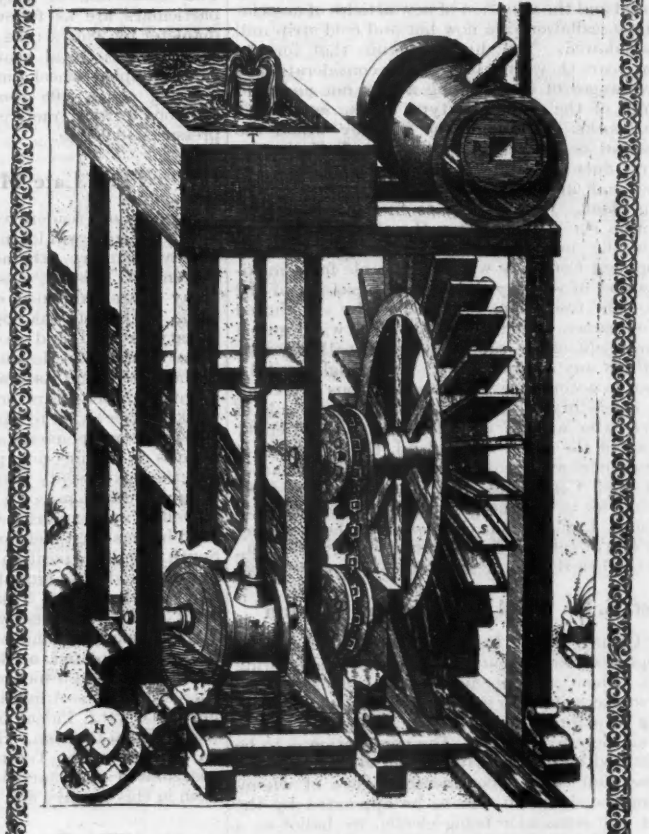
FIGVRE XXXVIII.



"THE ENGINEER" SWAIN SC.

DELL' ARTIFICIOSE MACHINE.

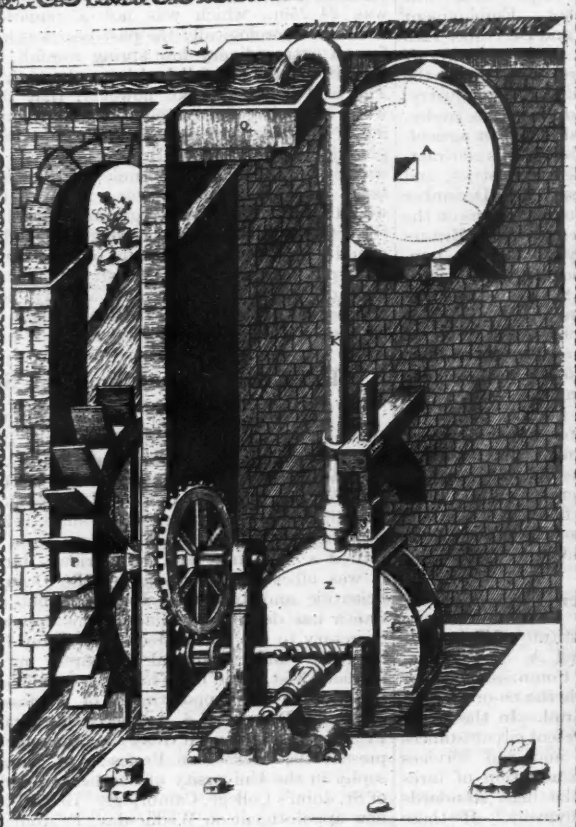
FIGVRE XXXIX.



"THE ENGINEER" SWAIN SC.

DELL' ARTIFICIOSE MACHINE.

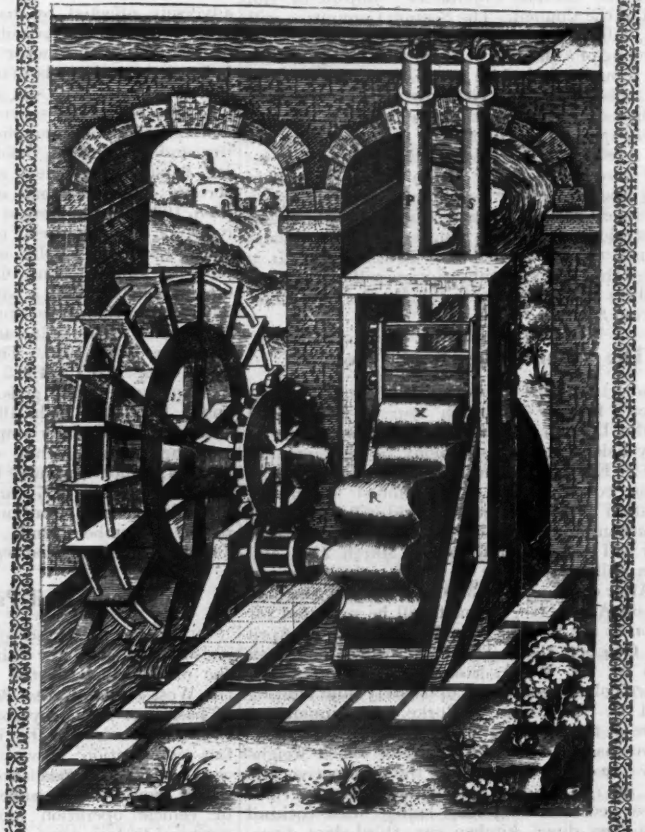
FIGVRE XL.



"THE ENGINEER" SWAIN SC.

DELL' ARTIFICIOSE MACHINE.

FIGVRE XLIX.



"THE ENGINEER" SWAIN SC.

FIGS. 1 AND 2—FORMS OF RAMELLI PUMP;
FIGS. 3 AND 4—FORMS OF "ABUTMENT" PUMP;

A History of Rotary Engines and Pumps

No. I*

INTRODUCTION

THE histories of nearly all the machines used by engineers at the present day are happy. They tell of a steady development from rudimentary beginnings and record a series of successful adventures as greater and greater things were attempted. Occasionally the general success is thrown into sharper relief by the details of a notable failure. The "Great Eastern," for example, was too great an advance to make in a single stride. Engineers learned by such failures and gained from them more value in added knowledge than they had lost.

But the story of positive acting rotary machines is an exception. For over one hundred years engineers and others struggled to bring into successful use a principle with undoubted advantages, but with hidden defects of a serious character. But with the exception of a few machines which served purposes that the reciprocating engine and pump could not adequately deal with, scarcely a single rotary proved really successful until the present century dawned. Even now the success that has been achieved, and the hope for better developments in the future are to be credited to a secondary class of machine. It is the pumps, the blowers, and the gas compressors that are now holding their own against the competition of machines working on other principles. The positive acting rotary engine, towards the invention of which so many bent their energies during the nineteenth century, was always doomed to fail. It is the intention of these articles to trace the melancholy history of rotary machines, and to discover, if that proves possible, what were those defects that ruined the prospects of the rotary prime mover and to record what are those improvements and what are those new conditions which have opened a field for the further development of the rotary pump and compressor.

The principle of the positive acting rotary has always had, and still retains, an extraordinary attraction for engineers. It offers a bewilderingly wide range of designs from the simple rotary piston travelling continuously in a circular path to the many varieties of "concealed reciprocator" in which, broadly speaking, a crank is held stationary whilst pistons and cyliners rotate around it. It includes the ingenious spherical engine of Dakeyne and its "relatives," engines based on the action of the universal joint, wheels of many kinds, intermeshing gears and screws, Roots and other blowers, excentric pumps, vane pumps, and many others. Several of the designs, more than might at a first examination be suspected, lie in a borderland in which it is difficult to determine whether in fact they are not in reality "concealed reciprocators." The Simpson and Shipton engine comes to mind as an example. Others, like the Dakeyne engine, are quite clearly reciprocators, but they have so much in common with rotaries and were at the time of their invention so commonly considered to be rotaries, that it would be ridiculous to exclude them from this history by attempting to draw too strict a line between the sheep and the goats.

Despite the enormous collection of specifications at the Patent Office, the variety is so endless that it is permissible to doubt whether every conceivable arrangement has yet been patented. In fact, it is probable that it is this very variety that has been the curse of the positive acting rotary. For an inventor, finding by experiment that his first scheme was faulty, was less likely to persist with it and by steady minor alteration to improve it than to turn his attention to another variety, and experience further disappointment. By contrast, the attention of succeeding generations of engineers has been continuously concentrated for a century and a half on the piston connecting-rod and crank mechanism, so that as a result of persistent minor improvement it can to-day be constructed to run at speeds which its first users would have regarded as fantastic, and which engineers of a mere fifty years ago would have thought attainable only by purely rotary devices such as turbines.

* Among sources for this section are :—Stuart's "Anecdotes," 1829: "Treatise on the Steam Engine," J. Scott Russell, 1841; "Hydraulic and other Machines," Ewbank, 1847; "Kinematics of Machinery," Reuleaux; The Science Museum. To the last mentioned we are indebted for permission to reproduce the five drawings—Figs. 1 to 5.

Rotary pumps were known and were perhaps in use at least as long ago as the sixteenth century. But it was not until the days of Watt that attention on any large scale was devoted to the development of rotary machines, whether as pumps or engines. It required, indeed, more than the mere advent of the steam engine to provide the necessary stimulus to inventive ability. Before Watt's days the steam engine was almost exclusively the "miners' friend." Its design and construction were particularly adapted for the purpose of pumping water from mines, and a reciprocating mode of operation had proved suitable. At the end of the eighteenth century, however, a demand began to grow, and its growth was accelerated by the improved performance of the Watt engine, for machines suitable for driving mills and other purely rotating machinery. The problem of the adaptation of the reciprocating engine for such a purpose was not found easy of solution, because in its then existing form the stroke of the engine was not fixed and was subject to variation according to the steam conditions and the duty. It was by no means obvious that the piston could be adequately controlled by a crank and fly-wheel, "an elegant application," of which, to quote

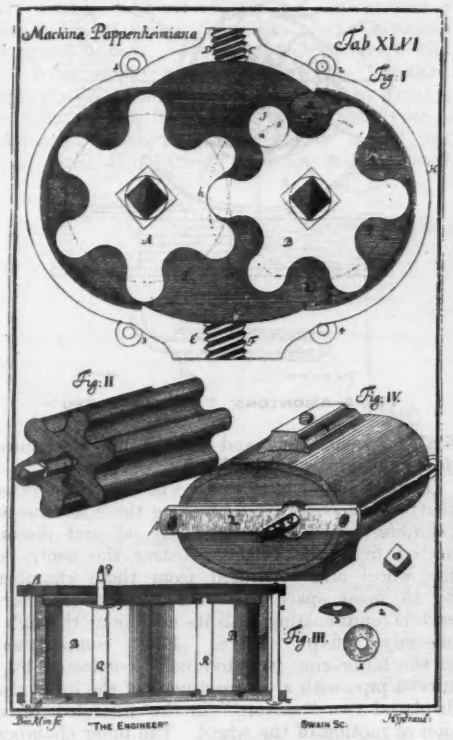


FIG. 5—PAPPENHEIM PUMP

from Stuart's "Anecdotes," "was to be found in most farmhouses in the country," so that "the common wheel for spinning flax was familiar to almost everyone from their infancy." Smeaton, for instance, wrote of the crank: "Great loss would be incurred by the absolute stop of the whole mass of moving parts, as often as the direction of motion is changed, and although a heavy fly-wheel might be applied to regulate the motion, it would be a great encumbrance to the mill," and in the *Philosophical Transactions* John Stewart expresses himself thus: "... the crank or winch is a mode of obtaining the circular motion which naturally occurs in theory, but in practice it would be impossible from the nature of the motion of the engine, which depends on the force of the steam and cannot be ascertained in its length; and therefore on the first variation the machine would be either broke to pieces or turned back."

In such circumstances and especially as various devices other than the crank, Watt's "sun and planet" motion excepted, proved unsuccessful, it was natural that the ideas of engineers should turn to the construction of an engine which would produce rotating motion directly and not by the conversion of reciprocating motion. The reciprocating engine had been devised to meet the requirements of a reciprocating pump. Then why should not a rotary engine be devised to drive rotary machinery? Watt was the first engineer of his day to attempt the experiment. Other engineers also developed the same "rotary fever," and Cameron, Murdock, and Hornblower, to mention only three who come easily to mind, all designed and experimented with rotary engines. Even the obvious success of the crank did not discourage early inventors. For quite apart from the thought that rotary machinery ought to be driven by a rotary engine, considerable misconception existed and persisted for fifty years thereafter as to the action of the crank mechanism, and it was believed that it was responsible for a heavy wastage of power. "At an early stage," says Ewbank in 1847, "it became the desideratum with engineers to obtain a continuous rotary movement of the piston-rod in place of the ordinary rectilinear and reciprocating one that the huge walking beam crank and connecting shaft might be dispensed with, the massive fly-wheel either greatly reduced or abandoned and the power saved that was consumed in overcoming their inertia and friction at every stroke of the piston." It was not appreciated that the energy absorbed in "overcoming their inertia" was returned to the machine by the fly-wheel whenever the moving parts were slowed down or stopped. As late even as the "'sixties" a correspondent to THE ENGINEER bases his recommendation of a very rudimentary and unpractical design of rotary engine on the loss of power incurred by transmitting the "force" of the steam into the inertia of the fly-wheel.

For the historian the material available is tantalisingly incomplete. There is no lack of record of the various designs that have been invented. The records of the Patent Office bear witness both to the frequently misplaced ingenuity of inventors and to their stubborn determination in face of discouragement. Up till 1910, according to "Barkers Mills to Turbines," there were nearly 2000 specifications filed for positive acting rotary engines alone. To these must be added many others with claims confined to pumping or ventilating. It is not then in the records of invention that the story is incomplete. The load of patent information is, indeed, somewhat staggering for the would-be historian to carry. Beyond it, however, material is lacking. Engineers, like other men, prefer to talk and write about their successes rather than their failures. Born and "perfected" on the drawing board, the rotary built under the protection of a patent might and sometimes did give promising results at a first trial. But sooner or later it was cast forth as worthless, to moulder to rust on the scrap heap. A few achieved at least the distinction of avoiding so ignominious a fate for a number of years. About this small minority more information is usually available, but not sufficient to relieve the historian of the responsibility of judging for himself what were those defects that led to failure. A residue remains. These rotaries achieved success early and maintained it. Contemporary journals provide the evidence of their steady progress and gradual improvement into the products of the present day. But, compared to the infinity of effort and the hours of careful labour of generations of inventors, the residue is as a mouse to a mountain!

ANCIENT MACHINES

The conception of a rotary machine probably dates as far back as that of the wheel. But except for wheels carrying buckets by means of which water might be lifted there seems to be no record of any positive acting rotary before the sixteenth century. By the end of that century, however, three rotary pumps were known, although evidence is lacking as to how widely they were used. It is perhaps a tribute to the insight of those early engineers who devised and improved them that of the three, two, much refined indeed, but not essentially altered, are still in use to-day.

Pappenheim—One of the earliest known rotary pumps is that ascribed variously to Grollier de Servière or to Pappenheim. The first-named is awarded the distinction of inventing it because it is described in the collection of mechanical and other devices published by his grandson in 1719. The pump is, however, described by a number of German writers as early as 1636 and is, indeed, so old an invention that it remains uncertain whether Pappenheim is to be regarded as the name of its inventor or the village in which he lived. It is variously represented, but is usually shown as a typical gear pump, a device of which it is the progenitor, with six teeth on each wheel, as shown in Fig. 5. One early writer gives it as many as nineteen teeth per wheel and others only four. In the latter case external gearing must have been required to retain a proper angular relation between

the two rotors. The drawing comes from Jacob Leupold's "Theatrum Machinarum," published early in the eighteenth century. Even in the six-toothed arrangement external gearing would have been an advantage, as the oblique action would have a tendency to damage the teeth. These early pumps were probably constructed of wood and were perhaps worked by two men throwing their weights on cranks.

Ramelli—Another celebrated pump is that described by Ramelli in "Le Diverse et Arteficiose Machine" (1588). The accompanying drawing, Fig. 1, derived from that work, shows an ambitious application of the pump, the internal arrangement of which is also shown. The pump consists of a cylindrical casing containing a drum able to rotate about an axis excentric to that of the casing, and so placed as just to touch the casing at one point. Within slots in the drum on two diameters at right angles are placed four vanes so arranged as to be able to slide in and out of the drum. In later re-inventions of the same pump, springs and other devices were utilised to hold the vanes out in contact with the casing, and in modern applications centrifugal forces are depended upon for the same purpose. The speed at which Ramelli's pump turned, however, can hardly have been sufficient for centrifugal force to make the blades work properly, and as no springs were used, he seems to have relied upon gravity, placing the centre about which the drum rotated in the upper part of the casing. It is possible that this reliance upon gravity accounts for the use of four vanes instead of two, which, at least for Ramelli's purposes, would seem to have been sufficient. For with only two vanes a condition might be reached in which one vane had fallen back into the drum under gravity while the other had not yet emerged. In such conditions the path between the suction and delivery ports would be open and the water could flow back unimpeded. The use of four vanes would render any such mischance impossible, except by the actual jamming of a vane within the drum. Ramelli speaks of the vanes as "paddles" and describes the pump as a "machine designed for the drawing of water from docks or foundations by the power of two men who turn the two cranks of an excentric wheel within the covering cylinder. The latter is made of metal or other suitable material closed and well fastened by screws. It has but one aperture for the entrance of water, and is firm and immovable. When the water enters the cylinder it is forced around by the movement of the wheel and its four sliding pieces (which move easily back and forth as required) continually through a tube." This device is no longer used, as far as the author knows, as a water pump. But, usually provided with an increased number of blades, it is the basis of a number of designs of rotary compressor, an application for which, as will be shown later, the design has specially advantageous qualities. As is shown by the second engraving, Fig. 2, from the same work, Ramelli also conceived that the blades might be hinged to the rotor, an arrangement less often used than the sliding blades, but which achieved distinction a century later in the Lemielle mine ventilator.

Abutment Pump—The third of the ancient pumps has no connection with any name, a fact which suggests to the author's mind that it is so very much the oldest that its original inventor has been quite forgotten. This conclusion is reinforced by the fact that its construction is just that which first leaps to the mind when the idea of the rotary is conceived. The pump consists of the usual cylindrical case within which concentrically mounted there is a drum of lesser diameter. This drum bears one or more projections which stretch across the intervening annulus between the drum and casing to act as "rotary pistons" driving the fluid before them and "squeezing" it against an "abutment" arranged in a gland, as shown in Fig. 3, so that it can be lifted out of the way to allow the pistons to pass. The contour of the pistons can take many forms, that shown being possibly the earliest, since it provides for a gradual lifting of the "abutment" by a cam-like action and its rapid return, when the piston has passed, under the influence of its weight. Certain other shapes of piston require the abutment to be mechanically operated by external means. The two pictures, both reproduced from Ramelli's work, in Figs. 3 and 4, show two varieties. In the second there are numerous pistons and the sliding vane carries a roller. Ewbank says of this type of pump that it is as old as the sixteenth century, and was probably known much earlier, and he points out its great disadvantage: "As the butment must be loaded with weights sufficient to overcome the pressure of the liquid column on the valve (otherwise it would itself be raised and the water would escape beneath it), the power to work this pump is therefore more than double the amount which the water forced up requires." Ewbank rather over estimates the theoretical disadvantage. It is the pressure that must be balanced, and if the "butment" is made narrow, a comparatively light weight can therefore be used and the power expended in lifting the "butment" is consequently reduced. In fact, however, the great friction at the "butment" gland introduces a heavy loss of power and the design is therefore unsatisfactory on this and other grounds.

Amontons—The earliest rotary engine about which sufficient facts are known to merit attention is that described by Amontons in 1699 as a "Moulin-a-feu." Amontons, from his earliest youth, was afflicted by deafness, a disability which debars the sufferer more from the delights of human companionship than perhaps any other so apparently slight an affliction. Unable to converse easily with others, he amused himself for many years by studying mechanical motions, and attempting the invention of a perpetual motion machine. Perceiving at last that he was wasting his time in such a search, he turned to more profitable speculations, and one of his mechanical designs is illustrated in Fig. 6.

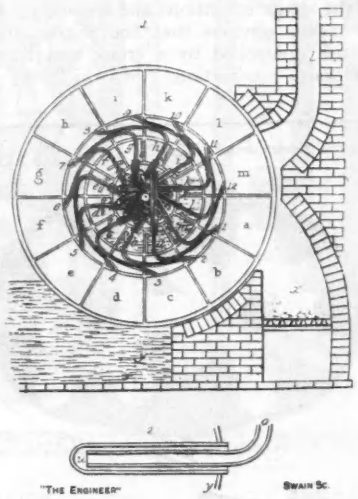


FIG. 6—AMONTONS' "MOULIN-A-FEU"

The machine consists of a wheel so constructed that on the outer circumference there are twelve chambers, each entirely sealed off and disconnected from the others. Nearer the centre of the wheel and separated from these chambers by an open space are twelve other chambers, each communicating with its neighbour through a one-way "flap" valve. Each compartment of the outer ring is individually connected by a curved pipe with a compartment of the inner ring displaced two "sectors" in the intended direction of motion of the wheel. The inner chambers are partially filled with water and the periphery of the wheel is exposed on one side to the heat of a fire and on the other side is immersed in cold water. As the wheel turns the water contained within the inner compartments tends to run down to that occupying the lowermost position, a course which is not impeded by the one-way "flap" valves which hang open on the upgoing side. The heat of the fire, however, causes the air in the outer chambers to expand, and in consequence pressure is exerted on the surface of the water within the inner chambers and it is caused to flow upward into the adjacent compartment on the downcoming side of the wheel, thus making that side preponderate and the wheel turn.

Amontons intended the wheel to have a diameter of 12ft. on the inner ring of chambers and a width of about 2ft. so that 754 cubic feet of water weighing 13,202 lb. should be enclosed. He calculated that one revolution would be completed in each thirty-five seconds and that the power obtainable would be equivalent to that of thirty-nine horses. To prevent water running out of the inner chambers to the outer, the connecting pipes, as shown in the engraving, were inserted at their inner ends into short pipes of larger diameter, closed at one end and communicating at the other with the chambers.

The design manifestly has some serious defects. "Like some of his contemporaries," says Stuart, "Amontons appears partial to the expansion of air and to have forced it into his service . . the water in the inner range of chambers would soon become intensely heated and form vapour which could not by any mechanism he has shown be prevented from filling what may be designated the air chambers." But, despite its defects, most engineers will agree with Stuart's further remarks. "Throwing the practical merit of this mechanism totally out of the question, the combination is exceedingly meritorious; and considering the time of its invention and the perfect novelty of the idea, it has many claims to a more favourable consideration as a first thought than has usually been awarded to it."

Leupold—Rather more than twenty years later, Amontons' machine was altered and simplified, but scarcely improved, by another talented writer. Leupold was the author of a collection of descriptions and drawings of machines begun in 1723 and continued for several years. The work shows him to have been more than a mere collector, for in numerous cases he has added to the machines he describes improvements of his own devising. His adaptation of Amontons' wheel is particularly ingenious and brings about a remarkable simplification. The inner ring of chambers (Fig. 7) is discarded and pairs of chambers on the periphery of the wheel are connected by straight diametral tubes. As each chamber passes through the heat of the fire the steam generated from the water it contains drives the remainder of the water up the tube to the chamber at the other end, thus causing one side of the wheel to preponderate.*

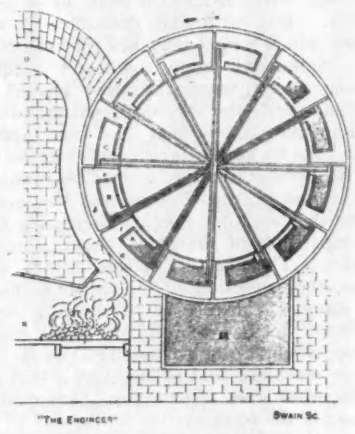


FIG. 7—LEUPOLD'S ENGINE

It has been said above that the change can hardly be regarded as an improvement. Leupold's wheel works, indeed, on a significantly different principle and, supposing the wheels would work at all, would have a very much lower thermal efficiency. Leupold's wheel acts purely gravitationally. But in Amontons' the pressure of the air drives the wheel round, using the water as an "abutment," just as in Watt's engine, described later, mercury is used as the "abutment." The amount of heat to be supplied in Amontons' wheel is that required to expand the air sufficiently to lift the water. All the heat that goes into the air plays some part in raising the water, and theoretically a thermal efficiency of the order of 10 per cent. would be attained by his 12ft. wheel. But in Leupold's machine a large amount of heat is wasted in heating and cooling the whole bulk of the water in order to produce an equivalent volume of steam, and reference to the steam tables shows that the heat actually producing steam is almost negligible compared with that required to raise the temperature of the water. The low efficiency of the wheel can best be illustrated by taking as an example a 12ft. wheel to correspond with that of Amontons'.

Assuming the "cold" side to be at 52·5 deg. Fah. and the pressure difference to be that corresponding approximately with a lift of 12ft. for the water, there are to be found in Callendar's Steam Tables the following entries:—

Pressure lb./sq. in. abs.	Temperature, deg. Fah.	Heat in water, B.Th.U.	Latent heat, B.Th.U.	Volume of steam, ft.³ per lb.
0·196	52·5	20·4	—	—
5·386	165·4	133·2	998·0	68·48

On the basis of chambers 1 cubic foot in volume sufficient heat is required to raise 62·4 lb. of water from 52·5 deg. Fah. to 165·4 deg. Fah. and to

* It is probable that Leupold expected the machine to operate by the expansion of the air in the outer chambers as in Amontons' machine but the action described seems as likely to occur.

produce 1 cubic foot of steam at the latter temperature.

Heat to raise temperature of water = 62·4 (133·2—20·4)
= 7040 B.Th.U.
Heat to produce 1 cubic foot of steam = 998/68·48
= 14·6 B.Th.U.

The work done is the raising of 1 cubic foot of water 12ft.

Work done: = 62·4 × 12/778
= 0·96 B.Th.U.

and it follows that the thermal efficiency is not much higher than one-tenth of 1 per cent. Curiously enough, the thermal efficiency rises the *warmer* the working range. It becomes, for instance, about one-half of 1 per cent. at pressures of about 200 lb. per square inch and temperatures of about 900 deg. Fah.

Despite the fact that Leupold's machine is thus unworkable on theoretical and probably practical grounds as well, it would be foolish to condemn the inventor. The machine is unquestionably more practical and simpler than Amontons', and, considering the lack of knowledge then existing with regard to steam, was an important advance, for which due credit should be granted to Leupold.

(To be continued)

Naval Construction in 1938

By HECTOR C. BYWATER, A.I.N.A.

No. II

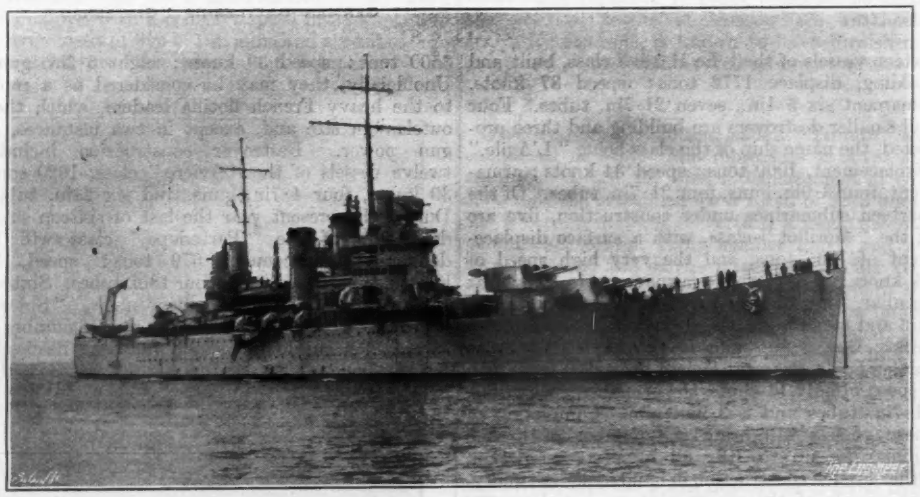
(Continued from page 4, January 6th)

United States

IT was announced at Washington in November that the United States warships and fleet auxiliaries then building and authorised represented a total of 400,000 tons. Included in this figure were six battleships of 35,000 tons, "North Carolina," "Washington," "Massachusetts," "Indiana," "South Dakota," and "Alabama"; the aircraft carriers "Wasp" (14,700 tons) and "Hornet" (displacement unknown); the 10,000-ton 8in.-gun cruiser "Wichita"; the two 10,000-ton 6in.-gun cruisers "St. Louis" and "Helena"; forty destroyers aggregating 65,000 tons; six submarines, and a number of depôt ships and tenders. Four more light cruisers, of 8000 tons or less, will be ordered early this year. It is an interesting fact that despite the rumours about monster Japanese battleships, the U.S. Senate in May of last year adopted an amendment limiting the new battleships to 35,000 tons—*i.e.*, the maximum reimposed by the London Treaty of 1936—"unless the President decides that other nations are building larger ships," when he may recommend raising the limit to 45,000 tons. The Bill to which this amendment related authorised an expenditure of £231,200,000 for the expansion of the Navy, and provided, in addition to four battleships, for two aircraft carriers, nine cruisers—all of 8000 tons or under—twenty-three destroyers, nine submarines, twenty-six auxiliary vessels, and 950 aircraft. Information as to when all these ships are to be commenced is difficult to obtain, but the following table shows the phenomenal—and to the British people the gratifying—expansion of the United States Navy during the past eight years in new vessels, completed, building, and authorised :—

Battleships: 6 of 35,000 tons, nine 16in. guns.
Heavy cruisers: 18 of 10,000 tons, nine or ten 8in. guns.
Light cruisers: 9 of 10,000 tons, fifteen 6in. guns; 9 of 8000 tons, twelve 6in. guns.
Aircraft carriers: 6 of 14,500 to 19,900 tons.
Destroyers: 99 of 1500 to 1850 tons.
Submarines: 45.

The position in relation to battleship construction is as follows :—The "North Carolina," of the 1937 programme, was laid down at New York Navy Yard on October 27th of that year; the "Washington," of the same programme, was begun at Philadelphia Navy Yard on June 14th, 1938. The first-named is due for completion at the end of 1941, the second in October, 1942. Of the four ships of the 1938 programme, the "Indiana" is to be built by the Newport News Company, the "Massachusetts" by the Bethlehem Company, Quincy, and the "South Dakota" by the New York Shipbuilding Company, Camden. The contract for the "Alabama" has still to be assigned, but is expected to go to the Norfolk Navy Yard. The estimated average cost of the six ships is £14,000,000. They are reported to be 750ft. long and to have a designed speed of 28 knots. The armament is to be nine 16in. guns in three turrets, with a numerous battery of 6in. guns and 5in. anti-aircraft pieces. Armour protection is to be massive, but is likely to be confined to vital areas. Towards the end of the year the "Wichita," eighteenth and last of the 10,000-ton, 8in. gun, cruiser type, to which the U.S.A. is entitled by Treaty, began her trials. She differs only in minor points from her immediate predecessors. During the past year seven of the nine cruisers of the "Brooklyn" class were completed. We illustrate the "Honolulu," a typical ship of the class herewith. They represent an exceptionally interesting and, apparently, successful type of "light" cruiser, the design of which is a notable achievement. Displacing 10,000 tons, they have machinery of 100,000 S.H.P. for 32½ knots. Their armament comprises fifteen 6in. guns in five turrets—three forward and two aft—and eight 5in. A.A. guns. The water line appears to have a 4in. belt and the turret faces are 5in. thick. An entirely novel feature is the situation of the hangar at the stern. Accommodating four to eight aircraft, it is equipped with a lift, two catapults and a powerful crane. The ships have a trim, clear-cut appearance, and present a more balanced design than that of the Japanese "Mogami" class, 8500 tons and fifteen 6·1in. guns, to which they were built as a reply. Pursuant to the six-year tonnage restriction fixed by Treaty, the four cruisers to be laid down this year—"Atlanta," "San Diego," "Juneau," and "San Juan"—will displace only 8000 tons and be armed with twelve 6in. guns. They will therefore resemble the British "Fiji" class.



AMERICAN "BROOKLYN" CLASS CRUISER "HONOLULU"

Having been delayed by serious mechanical defects, the aircraft carriers "Enterprise" and "Yorktown," 19,900 tons, which were launched in 1936, were not finally commissioned till the second half of last year. They have been previously described in these columns. A smaller carrier, "Wasp," of 14,700 tons, is completing, and another, "Hornet," is about to be ordered. Destroyer construction is proceeding rather slowly. Several of the 1850-ton class have taken over three and a-half years to complete, and few of the 1570-ton vessels have been delivered in less than thirty months. Heavy armament is a feature of all the new destroyers, the large ones mounting eight 5in. guns and twelve torpedo tubes, and the other type four to six 5in. guns, with, in some cases, as many as sixteen tubes. All the submarines now building are of standard design, with a surface displacement of 1450 tons. It is of interest to note that the speeds of U.S. submarines are never published officially. A fairly heavy programme of fleet auxiliaries, including destroyer depôt ships and aircraft tenders, is in hand and will be substantially expanded this year.

Japan

Owing to the complete absence of official information, little can be said about current Japanese construction. Most reports agree in placing the number of new battleships building and/or projected at four, but whether they are vessels of 35,000, 40,000, or 45,000 tons, as variously reported, is still undetermined. Two aircraft carriers of 10,050 tons are completing, and a third is reported to be on the stocks. The only definite item of news of technical interest is that in the last two cruisers of the "Mogami" class, 8500 tons, the armament has been reduced from fifteen 6·1in. guns to twelve. This is clear evidence that the first four units of the class were overgunned, and earlier reports that they behaved badly in a seaway and had suffered structural damage through the firing of full salvos, must now be accepted as true. Eight destroyers of 2000 tons, the largest ever built in Japan, are reported to be on the stocks, besides eight large submarines. In view of the present Japanese attitude of frigid secrecy regarding naval shipbuilding, it would be purposeless to devote further space to the subject.

France

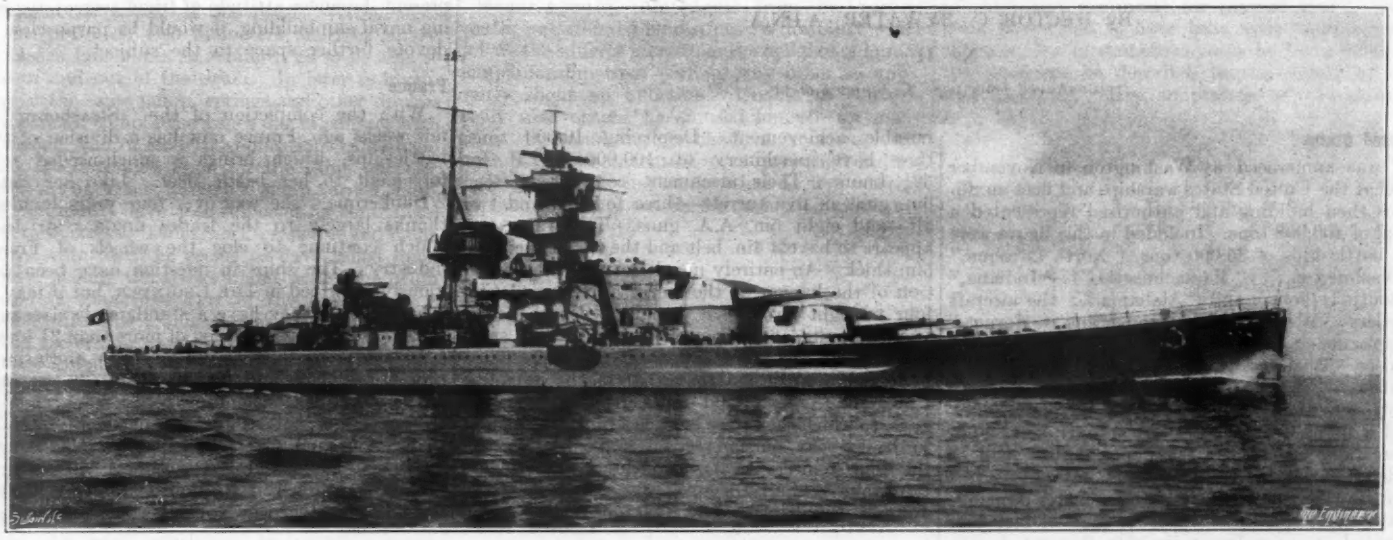
With the completion of the "Strasbourg" a few weeks ago, France now has a division of two battleships, which brings a much-needed reinforcement to her battle fleet. Like her sister, "Dunkerque," she was over four years building, thanks largely to the trades union restrictions which continue to clog the wheels of French industry. The ships in question have been previously described in THE ENGINEER, but it may be repeated that they have a standard displacement of 26,500 tons, a trial speed of more than 31 knots, a main armament of eight 13in. guns, and armour protection which accounts for about 38 per cent. of the total displacement.

Four larger battleships are, or shortly will be, under construction—"Richelieu," "Jean Bart," "Clemenceau," and "Gascogne." The first-named, laid down at Brest in October, 1935, was due to be launched in November last, but will not go afloat until January 17th this year. The "Jean Bart," begun at the Penhoët yard, St. Nazaire, in January, 1937, should leave the ways this year; the "Clemenceau" was laid down at Brest in December last (1938); and the "Gascogne" is to be put in hand at St. Nazaire early this year. All four ships are reported to be of uniform design, displacing 35,000 tons, with a length of 794ft., a breadth of 108½ft., and a mean draught of 26½ft. Geared turbine machinery of 155,000 S.H.P. is to be installed for a maximum speed of 30 knots. They are enlarged replicas of the "Dunkerque" class, the disposition of the main armament of eight guns in two quadruple turrets forward having been repeated, though the calibre has been increased to 15in. Great attention has been paid to protection, and it is unofficially reported that the total weight of armour will be 15,000 tons. The last of the quartet is due to be completed in 1941, but unless the *tempo* of construction is greatly speeded up, this forecast seems too optimistic. In November the first French aircraft carrier specially designed as such, to be named "Joffre," was begun at St. Nazaire, and a sister ship, "Painlevé," is to be started early this year. Beyond the displacement, 18,000 tons, no details of the type have been released. Work has begun at Lorient Dockyard on the first of three 8000-ton cruisers, the "De Grasse"; the others, "Chateaurenault" and "Guichen," have not been

allocated at the time of writing. They are described as improved editions of the "La Galissonnière" class, the main armament having been increased from nine to twelve 6in. guns. More cruisers will probably be provided during the current year. The flotilla leaders "Mogador" and "Volta" have at last been completed, the former having taken forty-two and the latter forty-five months to build. Displacing 2884 tons, they are the largest units of this type yet built in France. The contract speed is 38 knots, and the armament particularly powerful, comprising as it does eight 5·5in., eight smaller guns, and ten 21·7in. torpedo tubes. Having built thirty-two of these "pocket cruisers," France has now reverted to more moderate dimensions in her torpedo craft, for the sixteen vessels of the "Le Hardi" class, built and building, displace 1772 tons; speed 37 knots, armament six 5·1in., seven 21·7in. tubes. Four still smaller destroyers are building and three projected, the name ship of the class being "L'Agile." Displacement, 1000 tons; speed 34 knots; armament, four 3·9in. guns, four 21·7in. tubes. Of the fourteen submarines under construction, five are of the "Morillot" class, with a surface displacement of 1605 tons, and the very high speed of 23 knots. The torpedo armament is somewhat peculiar, nine 21·7in. tubes being built into the hull and two 15·7in. tubes carried, apparently, on deck. One 3·9in. gun is provided. The nine further boats, "Aurore" class, are of 805 tons, with a speed of only 14 knots, the armament being nine 21·7in. tubes and a 3·9in. gun. Completion of these vessels will bring the number of French submarines up to 101, all of post-war design. Other French construction in hand includes twenty-two vessels of the escort-minesweeper class, 630 to 647 tons, oil engines for 20 knots, two 3·9in. high-angle guns.

Italy

Italy shows no signs of abating her relatively prodigious effort to create a navy of commanding rank. She is spending vast sums of money on naval construction, and all her modern ships bear witness to the efficiency of her designers, shipwrights, and engineers. Of the four battleships in hand, the "Littorio" and "Vittorio Veneto," both launched in the summer of 1937, should be completed some time this year (their construction was delayed by the Abyssinian War); the "Impero" was begun at the Ansaldo yard, Genoa, on May 14th, 1938, and the "Roma" at Trieste on September 18th. They are understood to be identical, and the following details are official:—Displacement, 35,000 tons; 160,000 S.H.P. for 32 knots; length overall, 774ft.; breadth, 103ft.; armament, nine 15in., twelve 6in., twelve 3·5in. A.A., twenty A.A. machine-guns. The maximum thickness of waterline armour will be 12in. The designed speed is the highest of any capital ship now building, but in view of this and the heavy armament it is evident that there has been some sacrifice of protection. The reconstructed battleships "Conte di Cavour" and "Giulio Cesare" have proved very successful. Completed twenty-four years ago, they have been practically rebuilt. New machinery has increased the speed from about 22 knots to 27; in place of the original armament of thirteen old 12in. guns, they now mount ten 12·6in. of a new model, besides a powerful secondary battery. Protection has been strengthened throughout. In their new guise they are smart and handsome ships, constituting an impressive reinforcement of the Italian battle fleet. Two similar vessels, "Caio Duilio" and "Andrea Doria," launched in 1913, are now undergoing the same process of rejuvenation. The 1938 building programme included a group of twelve ships officially classed as "scouts," but which are, in effect, light cruisers. The names chosen for these vessels, such as "Scipione Africano," "Claudio Tiberio," "Pompeo Magno," and "Giulio Germanico," are obviously intended to reflect "the grandeur that was Rome." The only particulars so far released are:—Displacement, 3500 tons; speed 39 knots; eight 5·2in. guns. Unofficially, they may be considered as a reply to the heavy French flotilla leaders, which they outclass in size and, except in two instances, in gun power. Destroyer construction includes twelve vessels of the "Aviere" class, 1620 tons, 39 knots, four 4·7in. guns, and six 21in. tubes. During the present year the last of sixteen small destroyers of the "Partenope" class will be delivered—displacement, 679 tons; speed, 34 knots; three 3·9in. guns, four 18in. tubes. Sixteen similar, but slightly smaller, units, "Spica" class, are already in service. The precise number of submarines building has not yet been disclosed, but is believed to exceed thirty-two. If this figure is correct the Italian submarine flotilla will eventually number 123 units, of which all save half a dozen will be of modern type. It has been officially stated that a certain number of the submarines now in hand will be able to cruise from Italy to the Red Sea, *viâ* Gibraltar, without refuelling. The Italian shipyards are now building naval tonnage of all types with a rapidity which is certainly not excelled, even if it be equalled, in any other country.



GERMAN BATTLESHIP "GNEISENAU"

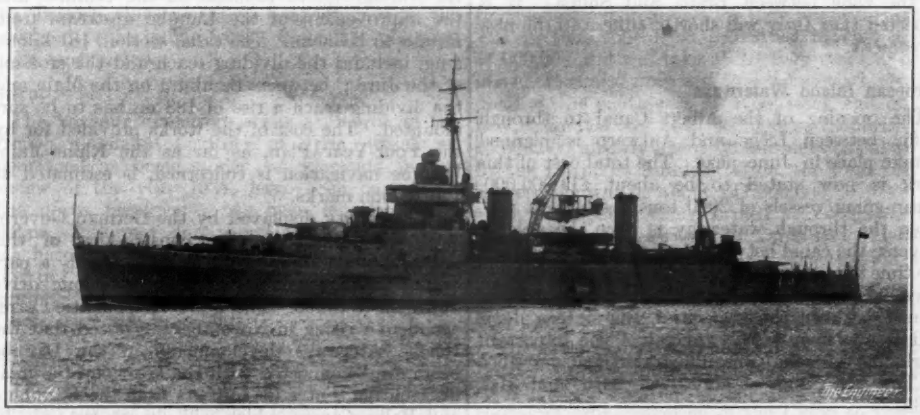
Germany

German naval expansion is proceeding steadily within the framework of the Anglo-German treaty of 1935, which limits the combatant tonnage of the Reich to 35 per cent. of the British Imperial aggregate. It is pleasant to be able to record that this agreement is being faithfully observed. Whatever the position may be in other respects, there is at least no rivalry at sea between the two Powers. The most important naval event in Germany during the year was the completion, in May, of the battleship "Gneisenau," followed in the late autumn by the delivery of a sister ship, "Scharnhorst." Not unnaturally the German Press emphasised the significance of the occasion, pointing out that these were the first warships—apart from submarines—which had been built in defiance of the restrictions imposed by the Versailles Treaty. The "Gneisenau" was described in last year's review: Displacement, 26,000 tons; contract speed, 27 knots; armament, nine 11in. guns in triple turrets, two forward, one aft. The relatively light weight of the main armament indicates that a high percentage of the total displacement is devoted to protection. Photographs reveal a thick belt of armour extending from the forward turret to a point well abaft the after turret and carried up to the main deck. The ships present a handsome and imposing appearance reminiscent of the later German battle cruisers of the war period, though the outline is rather impaired by the massive tophamper necessitated by the modern system of gunnery and searchlight controls and aircraft equipment. An unusually interesting ship is the aircraft carrier "Graf Zeppelin," launched at the Deutsche Werke, Kiel, on December 8th. Not only is she the first carrier to be built for the German Navy, but she appears to approach more closely than any other vessel of her type the ideal of a composite "aircraft cruiser" which has many advocates in naval circles. Particulars are as follows:—Displacement, 19,250 tons; length, 820ft. 3in.; breadth, 88ft. 6in.; capacity, 40 aircraft; geared turbine machinery, contract speed 32 knots; armament, sixteen 5·9in. guns, ten 4·1in. A.A., and twenty-two automatic A.A. pieces. An authoritative German writer* has stated that the vessel has very strong protection. Launch photographs show an extensive and deep armour belt, and there is reason to believe that the "Graf Zeppelin" is unique in having an armoured flight deck. If this conclusion is well-founded she is much less vulnerable than the ordinary carrier, and thanks to her protection and powerful armament, she should be able to hold her own in a duel with a light cruiser. It goes without saying that a ship of this type, at

GERMAN DESTROYER "HANS LUDEMANN"

* In the "*National Zeitung*" November 29th.

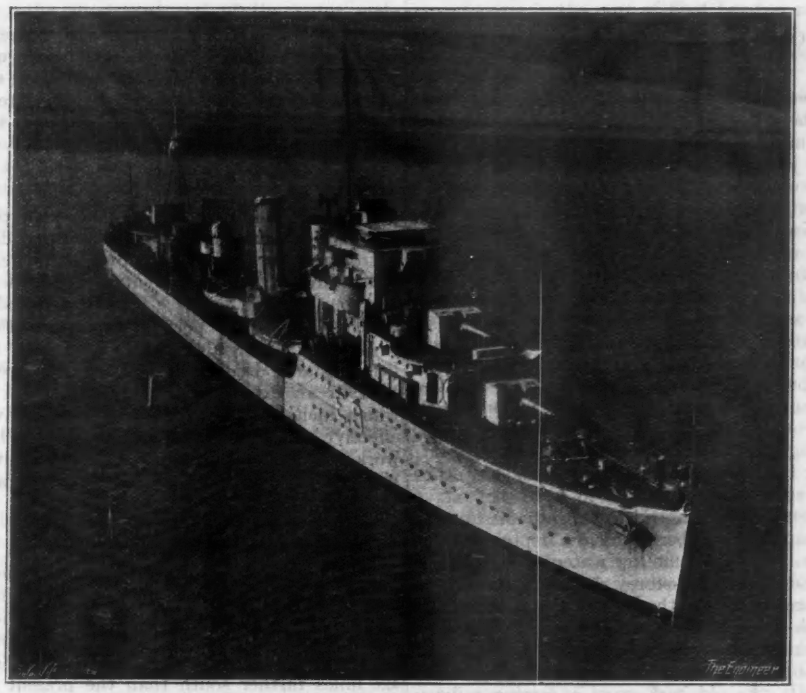
large on the ocean trade routes, would introduce a new and very formidable factor into naval strategy. So much has, indeed, been hinted by the German writer referred to. A sister ship to the "Graf Zeppelin" is due to be launched early this year. With the launching on August 22nd of the "Prinz Eugen," the last of the three 10,000-ton, 8in. gun cruisers, to which Germany had, for the time being, voluntarily restricted herself, is afloat. Her predecessors, "Blücher" and "Admiral Hipper," both launched in 1937, will be completed in the current year. Particulars of this type were given in the previous annual review. The designed speed is 32 knots, the main armament eight 8in. guns, and the water line belt 5in. in thickness. They are, in fact, armoured cruisers of a type which the British Navy would now possess but for the ill-judged action of the Government in cancelling in 1931 the orders for the "Surrey" and "Northumberland."* Two "light" cruisers, provisionally known as "K" and "L," are to be launched this year. Displacement, 10,000 tons; length, 653ft.; breadth, 71ft.; speed, 32 knots; main armament, twelve 5·9in. As will be noted, in size and gun power they resemble the British "Edinburgh" class. It is possible, in view of Germany's recent decision to claim the full quota of five 8in. gun cruisers to which she is legally entitled by the Anglo-German naval agreement, that the "K" and "L" will be redesigned to carry an 8in. armament. Four smaller cruisers are building, known as "M," "N," "O," and "P." They will displace 7000 tons and be armed with eight or nine 5·9in. guns. The sixteen large destroyers of the "Leberecht Maass" type, authorised in 1934–35, have all been commissioned. They are vessels of 1625 tons and 36 knots speed, mounting five 5in. guns and eight torpedo tubes. Fourteen heavier destroyers, 1811 tons, are in varying stages of construction, some being already in commission, of which one is the "Hans Lüdemann." They have the same speed and armament as the "Maass" type. Eighteen torpedo boats are on the stocks and twelve more will be started this year. Details: 600 tons, 36 knots, one 4·1in. gun and six tubes. The total number of submarines completed and building is seventy-one. Of these, the majority are medium-sized boats, from 500 to 740 tons; the remainder are coastal units of 250 tons. This formidable submarine force has sprung into existence in less than four years. Germany is now claiming full parity with the British Commonwealth in submarine tonnage as provided for (subject to friendly discussion beforehand) in the Anglo-German agreement of 1935. Should this claim be pressed she will add about 45,000 tons to her submarine programme. Further construction includes twelve motor torpedo boats and several fleet tenders and depôt ships.



ARGENTINE CRUISER "LA ARGENTINA"

Russia

Reports that two or more battleships of 35,000 tons, to be armed with 16in. guns, are building or projected must be accepted with reserve. Negotiations for the construction of these vessels in the United States appear to have broken down, and it is most improbable that they could be built from domestic resources. On the other hand, there is positive evidence that a big programme of lighter warships is well under way. A new cruiser, "Kirov," was completed late in 1937; a second, "Maxim Gorki," entered service last month (December); and two further units, "Kubyshev" and "Orjonikidze," are due for delivery this year. The first two were built at Leningrad, the second pair at Nikolaieff, on the Black Sea. As reported, their particulars are:—8500 tons, 35 knots, six 7·1in. guns, four 4in. A.A., and six torpedo tubes. Nine large flotilla leaders of 2600 tons, apparently of Italian design, are in hand at Leningrad. They are credited with a contract speed of 38 knots and an armament of five 5·1in. guns and six tubes. So persistent are the reports of submarine construction on a mammoth scale that it is impossible to dismiss them as chimerical, but the total of nearly 170 Russian boats—ranging from large ocean-going types to very small coastal units—given in the German textbooks requires confirmation. Should this figure be anywhere near the truth the present-day naval forces of the U.S.S.R. must be treated with more respect than they have hitherto received. What does seem to be evident is that in the rebuilding of its navy the Soviet Government enjoys the assistance of technicians supplied by other countries to which the political tenets of Moscow are anathema. Italy, for example, is known to have furnished a great deal of material, as well as expert advice.

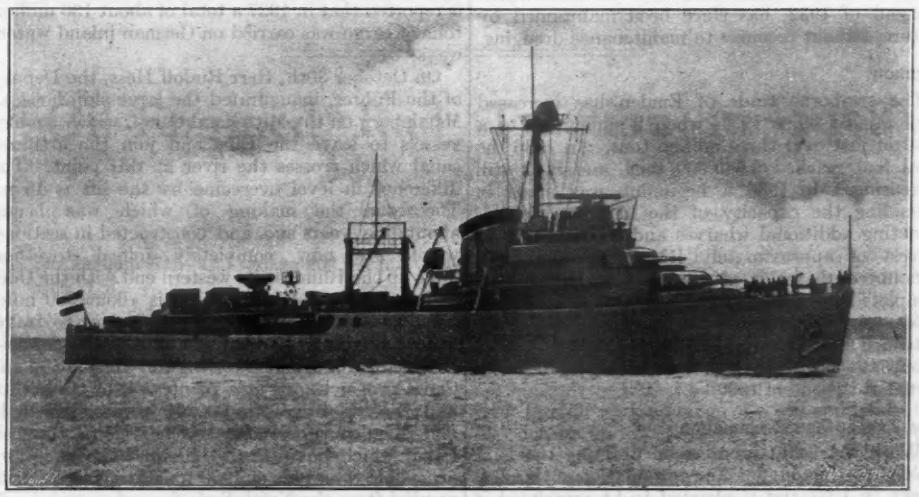


ARGENTINE DESTROYER "SAN JUAN"

Other Navies

The Netherlands flotilla leader "Tromp" was completed in May. She represents a novel and ambitious design, for with a displacement of only 3350 tons she is engined for a speed of 32·5 knots, has a certain amount of vertical armour defence, mounts six 5·9in., eight smaller guns, and six torpedo tubes, and carries a seaplane. After very successful trials she visited Portsmouth where she was much admired. A sister ship is now on the stocks. Two cruisers, at present unnamed, are building: 8350 tons, 33 knots, ten 5·9in. in two triple and two twin turrets, fourteen small A.A. guns, six torpedo tubes. Two aircraft will be carried.

During the year the training cruiser "La Argentina," 6500 tons, built by Vickers-Armstrongs at Barrow, and the seven destroyers ordered from British yards in 1936, were delivered to the Argentine Government, one of which is the Brown built destroyer "San Juan." Six Brazilian destroyers similar to the British "Intrepid" class, 1375 tons, are now building in this country, two each by Vickers-Armstrongs, J. S. White and Co., and J. I. Thornycroft and Co. It is reported, but not yet confirmed, that two Chilean cruisers of 8000 tons will be ordered from British firms this year.



NETHERLANDS FLOTILLA LEADER "TROMP"

* Unlike the preceding units of the "County" class, which have only scanty protection, these ships were designed with strong armour over vital parts and elaborate underwater defence.

Harbours and Waterways in 1938

No. II

(*Continued from page 36, January 6th*)

EUROPEAN PORTS AND WATERWAYS

France

THE reconstruction of the Bassin de la Joliette at Marseilles, which has been in progress since 1932, is nearing completion. Three out of the four oblique jetties, each about 280 m. in length, which project from the old east quay wall of the *bassin*, will be in use early in 1939. The fourth jetty, No. 2, is still under construction. The removal of the old moles at the northern end of the *bassin* and the construction of the new Digue St. Jean at its southern end have nearly doubled the enclosed area. These works were completed about three years ago. Since 1932 there has also been constructed the new Digue Ste. Marie, over 300 m. long, which protects the *avant-port* Joliette. When the remodelling of the *bassin* is completed, it will provide sixteen berths for ocean liners, 500 m. of quayage for coasting vessels and inland craft, and over 110,000 square metres of sheds and other covered spaces.

The jetties vary in width between 50 m. and 72 m., and the liner berths have a depth of water of 8·5 m. below extreme low water. Three jetties are provided with two-storey sheds and one with a three-storey shed. All the liner quays are equipped with high-level covered travelling passenger gangways, which are adjustable for level. There are sixteen of these structures, one for each liner berth. On the old east quay a marine railway station has been constructed with enclosed connections between it and each of the sheds on the jetties. The berths are also equipped with fifty-six cargo cranes of various capacities.

Work was begun early in 1937 on the improvements at the P. & O. Quay at Cap Janet, which lies between the modern Mirabeau and President Wilson *bassins* at the northern end of the port of Marseilles. Accommodation is being made at the quay for three liners, each 660ft. long, and a new *gare maritime*, with Custom's hall, moving stairways, lifts, and other modern conveniences, is being built to facilitate the embarkation and disembarkation of passengers and mails. In 1936 over 9¼ million tons of goods and 714,578 passengers passed through the port of Marseilles.

The completion of the new outer harbour and other works included in the improvement scheme initiated at Dunkirk nearly ten years ago has repeatedly been delayed and is still some way from realisation. The Port Authorities have, nevertheless, prepared further plans for port development, which will be undertaken as soon as the main programme has been got out of the way. These further works include a large dry dock of 300 m. usable length and the segregation of the oil trade in the port. No less than 1,200,000 tons of liquid fuel are handled in the port annually.

The dredging of the new entrance channel through the sea bar of the River Gironde by the suction dredger "Pierre-Lefort," which we described in our issue of April 7th, 1933, has, according to a statement made by Monsieur Lévêque, the Chief Engineer of the Port of Bordeaux, proved so successful that the depth of 9·5 m. below chart zero, which was the ruling depth when the operations were concluded about the end of 1932, has since been maintained by Nature without recourse to maintenance dredging.

Germany

The sea-borne trade of Emden has increased very rapidly since 1931, when it amounted to a total of just over three million tons. In 1936 the total had reached 9,640,000 tons, and it is still increasing. In 1936 a beginning was made in extending the capacity of the harbour by constructing additional wharves and transit sheds at a cost of approximately RM. 7,000,000. It is announced that this programme of work will be completed during 1939. The fishery harbours of Cuxhaven, Wesermünde, and Bosüm are being extended and improved at a cost of RM. 20 million. Work was begun in 1937 and is due to be completed at the end of 1939.

The Zuyder Zee Reclamation

Work is now in progress on draining the N.E. Polder of the Zuyder Zee reclamation; this was begun in 1937 and is planned to be completed in 1941. The N.E. Polder covers 120,000 acres, nearly one-fifth of the total area to be reclaimed in the Zuyder Zee. The Wieringermeer, or N.W. Polder, 50,000 acres, drained in 1930, is the smallest of the four areas. The two remaining areas, still undrained, the S.W. and S.E. Polders, together make up about 380,000 acres.

Denmark

The Harbour Board of Copenhagen completed in 1936 the construction of an isolated and detached petroleum port in the Sound over two miles to the southward of the main entrance to the Outer Harbour of Copenhagen. The site selected as the nucleus of the oil port is the dismantled fort Provisten. Moles and jetties have been built, a berthing area dredged and a land area reclaimed. In 1937 an extension of the oil port was begun, which includes the building of a pier having an effective area of 60,000 square metres. When this work is completed the whole of the petroleum spirit business in the port will be concentrated at Provisten.

The Sulina Mouth of the Danube

The continued and rapid shoaling of the Sulina mouth of the Danube, due to sediment from the Kilia mouths to the northward, has induced the Commissioners to consider the formation of a new cut for the Sulina Arm, entering the Black Sea some six miles further south than the present mouth, where littoral currents and wave action may be more favourable to the maintenance of an effective channel. This proposal is to be further investigated. The system of international control of the lower river by the European Commission of the Danube has been modified by agreement between Great Britain, France, and Rumania, by which Rumania will in future control the execution of new works in the region of the Danube mouths and in the zone between Braila and Sulina. It is expected that Italy will shortly adhere to the new agreement.

European Inland Waterways

The opening of the Albert Canal to through traffic between Liège and Antwerp is planned to take place in June next. The total cost of this work is now stated to be about £14,000,000. Ocean-going vessels of 2000 tons deadweight will, when the through waterway is open, be able to traverse the canal between Antwerp and Liège and the time of transit will be reduced to two and a-half days, whereas, before 1929, the duration of water transit between the two cities was sixteen days, and is now five days. Several of the important works on the canal were illustrated and described in THE ENGINEER of May 17th, 24th, and 31st, 1935.

The financial situation of France has had the result of slowing up the expenditure from State funds on public works. The credits voted for French inland waterways during the past year were little more than sufficient to meet the cost of maintenance and repairs.

In Germany, on the other hand, canal construction and the improvement of river navigation were carried on with almost feverish activity. It is reported that in 1937 a total of about 130 million tons of cargo was carried on German inland waterways.

On October 30th, Herr Rudolf Hess, the Deputy of the Führer, inaugurated the large ship hoist at Magdeburg on the Mittelland Canal, which enables vessels to leave the Elbe and join the artificial canal which crosses the river at this point. The difference in level overcome by the lift is 18 m. The canal, the making of which was begun about fifty years ago, and constructed in sections, which are now completely joined together, links up the Rhine at its western end with the Oder at its eastern end. The canal is about 300 miles long, and it is now possible for barges to travel from Basle in Switzerland to Königsberg in East Prussia or from Emden to Breslau. The Mittelland Canal proper begins at a point west of Osnabrück and runs east by Minden, Hanover, Brunswick and Magdeburg, beyond which it joins the Ihle Canal which links it with Berlin. Berlin is now accessible to vessels of 1000 tons carrying capacity coming from the North Sea.

Field Marshal Göring, as Commissioner for the Reich Four-Year Plan, has announced that the Rhine-Main-Danube Canal is to be completed by 1945. The first practical step towards forming an artificial link between the Rhine and its tributary the Main and the Danube was begun by King Ludwig of Bavaria, who between 1836 and 1848 built the Ludwig Canal which links Bamberg, on the Main, to Kelheim on the Danube. The old canal forms the basis of the new and much enlarged one now under construction. The Ludwig Canal could only accommodate barges of 120 tons capacity, whereas the new canal will carry river steamers and barges of 1200 tons. Work was begun on the new Rhine-Main-Danube Canal in 1922, but until the advent of the new regime in Germany the progress of the undertaking was slow and the funds provided for the work altogether inadequate.

Since the *Anschluss* the work of construction appears to have been speeded up tenfold, both on the canalised Main and on the Ludwig Canal section. The River Main is now navigable by ships of the standard size of 1200 tons from Mainz, at its confluence with the Rhine, as far as Würzburg. The standard boat has a length of 80 m., a beam of 10 m., and a draught of 2·3 m. The dimensions planned for the waterway will, however, permit the Rhine boats of 1500 tons, which have a length of 85 m. and a beam of 10·25 m., to navigate the waterway. Trains of boats on the canalised Main usually comprise three 1200-ton barges towed by a 300 H.P. tug at a speed of 4 kilom. to 5 kilom. per hour when proceeding upstream and at 7 kilom. to 10 kilom. per hour when going downstream. On the Bamburg-Nuremberg Canal section the boat trains will usually consist of two barges and a tug.

All the barrages on the canalised Main will ultimately be provided with twin locks, but in the first instance one lock only is being built at each dam, except on certain sections where the amount of traffic is expected to be exceptionally large. On some sections the locks have a working length of 300 m. and on others of 230 m. or 225 m.

The work that remains to be done to complete the enlarged waterway comprises the canalisation of the Main from Aschaffenburg to Bamberg, the construction of a canal from Bamberg on the Main, *viâ* Nuremberg, to Kelheim on the Danube, and the improvement of the Danube upstream from Passau to Kelheim. The canal section, 181 kilom. long, includes the dividing reach and the crossing of the Jura; between Bamburg on the Main and the dividing reach a rise of 188 m. has to be surmounted. The cost of the works provided for by the Four-Year Plan, as far as the Rhine-Main-Danube navigation is concerned, is estimated at 750 million marks.

The activity displayed by the German Government in pushing on the construction of this important inland waterway is undoubtedly a part of the preparations for a great economic drive down the Danube. *The Times'* Diplomatic Correspondent writing in November suggested that the Reich waterways developments in the Danube basin are "connected with the creation of a great distributive centre for imports from the Danubian and Balkan areas, which will almost certainly be established in Vienna."

Other German waterways on which large-scale improvements are being made are the Neckar Navigation, the Dortmund–Ems Canal, the Rhine–Herne Canal, the Weser (whose middle section from Minden to Bremen is being canalised), and the Werra between Münden and Wartha, which is also being canalised.

We have from time to time referred in our annual reviews to the progress made by the Soviet Government with the execution of the revised programme of canal construction entered upon in 1931. The whole scheme includes the White Sea and Baltic canal, 227 kilom. long; the Moscow and Volga canal, 128 kilom.; the Volga and Don canal, 109 kilom.; the reconstruction of the Mariinsky and Moscow River navigations; and the improvement of the River Dneiper for navigation along its whose course. The White Sea and Baltic canal was officially opened to navigation in June, 1933. The Moscow and Volga canal, begun in 1932, was declared ready for navigation in July, 1937, and work on the other waterways named is still in progress.

The canal which has been cut from the port of Leghorn to Pisa has recently been completed at a cost of 50 million lira. It is navigable by craft of 600 tons.

THE NEAR EAST

The Suez Canal

The Suez Canal Company has for a long time past experienced difficulty in maintaining the

desired depth in the channel that gives access from the sea to the canal at Port Said. The 39ft. depth sea-bed contour that corresponds to the normal depth in the canal is now more than 5 miles from the shore, and tends to become more distant. The Canal Company recently decided to build a new and very powerful suction dredger of similar type to the dredger "Pierre Lefort," described in our issue of April 7th, 1933, which was so successful in dredging the sea-bar of the River Gironde. The dredger "Chien-She," built in Germany about three years ago for the work of dredging a channel through the Fairy Flats of the Yanztse bar, is of similar type to the "Pierre Lefort." The dredger which the Suez Canal Company is about to build will, it is understood, be of still greater size and power than either of the dredgers mentioned.

The canal traffic for the year 1937 surpassed all previous records; 6635 vessels passed through the canal compared with 5877 in 1936. The total net tonnage for the year amounted to 36,491,000. The commercial tonnage using the canal increased by over 20 per cent. British tonnage represents nearly one-half of the shipping using the canal.

Turkey

The negotiations between Turkish bankers and the Export Credits Guarantee Department relative to a new Turkish loan to be devoted principally to public works, resulted in June last in the announcement that a credit of £16,000,000 had been granted to Turkey. It has since been announced that the Turkish Government proposes to expend a large part of the credit in connection with the enlargement and modernisation of the ports of Istanbul and Smyrna and the construction of new ports at Tchatal-Agzi and Trebizond on the Black Sea. The first, estimated to cost about £2,000,000, will be used for the shipment of coal from the Zonguldak coalfields and will also serve the iron and steel works now being built at Karabuk. The port works at Trebizond are intended as a terminus of the Tebriz-Trebizond transit road. Another port has been planned at Mersina, on the Mediterranean, which will serve the southern and south-eastern parts of Anatolia. Sir Alexander Gibb has, since 1936, been advising the Turkish Government in connection with the port and other public works which are proposed to be constructed.

Beirut

The harbour extension works at Beirut in the French mandated territory of Syria, which we mentioned as being under consideration in our review of the year 1934, have been completed. The north breakwater has been lengthened by 492 m., and new quayage, 427 m. in length, has been constructed with a depth alongside of 11·5 m. at low water. Two additional quays totalling 338 m. in length with a depth of water of 7·5 m. have also been built.

Palestine

The secondary port of Jaffa at Tel Aviv was officially opened for passenger traffic by Sir Arthur Wauchope, then the High Commissioner for Palestine, in February, 1938. The port works, designed for the accommodation of lighters and other small craft, were begun in 1936, and in 1937 the small harbour was brought into use for goods and merchandise traffic only. The port serves the new and rapidly growing Jewish town of Tel Aviv, a short distance north of Jaffa. A reinforced concrete jetty costing about £164,000 which has been under construction by the Government Harbour Authority at Haifa was completed during the year.

AFRICA

Cape Town

We have on other occasions made reference to the large scheme of harbour extensions at Cape Town, work on which was begun towards the end of 1937, when a contract for the first section of the works was placed with the Hollandsche Aanneming Maatschappij. The contractors have already assembled a considerable fleet of dredgers, tugs, and other floating craft required for the work. The first part of the programme to be undertaken includes the removal of the existing random-block mole, the material from which will be used again, in the construction of a part of the retaining walls to enclose the area to be reclaimed from the sea. The main contractors have also begun the construction of the outer mole, or sea wall, which will extend from near the end of the existing random-block mole (to be removed), towards the Woodstock Beach on the opposite side of the bay. This mole comprises two lines of steel sheet piles, the space between them being sand filled. While this work is in progress another firm of contractors, Christiani and Nielsen, of Copenhagen, with whom a subsidiary contract of the value of £278,000 has been placed by the Harbour Administration, are constructing the shoreward end of the outer mole starting from a point on the Woodstock Beach and running in a north-westerly direction to join the section of the work which is being carried out by the Dutch contractors. It is expected that the two sections of the outer mole will be joined about the end of 1939, when this work, nearly 1½ miles long, will be completed. The shoreward section of the outer mole is being constructed of reinforced concrete and contains an internal aqueduct which will form a new water intake for the Salt River power station.

The South African Railways and Harbours Administration are carrying out by direct labour a section of the harbour works, including the quay wall of the new berths for ocean liners which is to be made on the foreshore, parallel with the outer mole, and behind which lies the greater part of the area to be reclaimed.

Concurrently with the construction of the outer mole and the building of the quay walls for the liner berths, dredging is in progress on the site of the new basin, the dredged material being pumped ashore behind the walls. Included in the main contract is the breaking up and removal of about 2,000,000 tons of rock from the bed of the bay. For this work the Dutch contractors have had built a large drilling craft equipped with a battery of compressed air submarine drills of German design and manufacture.

The Prime Minister of the Union of South Africa, General Hertzog, formally inaugurated the work of making the harbour extension on May 10th, 1938, by setting in motion the machinery of one of the dredgers working in the basin area. Simultaneously he switched on a thousand electric lights which had been placed in position outlining the new harbour area.

We described and illustrated the harbour project in our issue of October 15th, 1937. The plans we then reproduced have undergone some modifications since, but in substance they are still correct. The present scheme is estimated to cost about £6,000,000 and will take about four years to complete. It is also proposed to construct a large dry dock at the south-east or Woodstock end of the new basin at a cost of £1,000,000, so that with the £4,000,000 already spent on the new basin works by the Harbours Administration, the total cost of the project will be about £11,000,000.

An oil depôt is being formed at Yserplaatsvlei, about two miles eastward of Table Bay Harbour, where storage for 128,800 tons of petroleum and petroleum spirit is to be provided.

East London

The extension of the south breakwater of East London by 600ft., begun in May, 1936, has been completed and authority has been given by the Harbours Administration of the Union to proceed with a further extension of 400ft., which, when completed, will make the total length of the breakwater 3400ft. The cost of the 600ft. extension, which has been carried out by dumping, pellmell, a mound of 30-ton concrete blocks up to the level of low water of ordinary spring tides, upon which a solid mass concrete superstructure has been founded, has been £150,000. The additional length of 400ft. now sanctioned is estimated to cost £69,500. The turning basin and wharves constructed in the Buffalo River at East London, completed towards the end of 1937, formed the subject of an illustrated article which we published in our issue of February 25th, 1938. An illustration of the port appeared in one of our Supplements last week.

The improvements that have been made in recent years in the port of East London at a total cost of nearly £1,500,000, have made it possible for the larger class of ocean liners to make use of the port. The Union-Castle liner "Athlone Castle," of 25,500 tons, entered the river and berthed at the quay soon after the turning basin was completed.

Durban

The 4000-ton floating dock, an order for which was placed by the Union Harbours Administration in 1937, was launched at the Haverton-on-Tees shipyard of the Furness Shipbuilding Company on July 28th last. The dock has an overall length of 350ft. and a clear width between fenders of 64ft. The total cost of the dock with its berth will approach £200,000. The floating dock is to be moored on the Congella side of Durban Harbour near the large dry dock and the site selected for the new seaplane base.

Beira

The extension of the deep-water wharves and the construction of two large transit sheds in the port of Beira, which were begun by the Beira Works, Ltd., in April, 1937, are expected to be completed and ready for use in March, 1939. The new wharf comprises an open-work structure, 600ft. long, supported on cast iron screw cylinders. A further extension, comprising a fifth wharf, 600ft. long, of similar construction, was begun last year and is expected to be ready for use by the end of this. The cost of the extensions, including dredging, reclamation work, &c., is estimated to be £500,000. The tonnage dealt with at the Beira wharves is steadily increasing and the traffic for the year ending March 31st, 1938, over 1½ million tons of goods, shows an increase of nearly 47 per cent. on the figure for the previous year. Messrs. C. S. Meik and Halcrow are the consulting engineers.

Other African Ports

The French Colonial Administration has decided to deepen the harbour of Dakar, in French West Africa, to provide an anchorage suitable for war vessels. The work has been begun and is estimated to cost about £180,000.

The French Colonial Government of Algeria has recently completed the construction of quay walls at the small port of Arzeu, about 20 miles east of Oran, and quay construction at Mostaganem, another minor port 50 miles east of Oran, has now been begun.

The only natural harbour in Italian East Africa is at Massawa, in Eritrea, nearly 1000 miles from Addis Ababa. At Assab at the southern end of the Red Sea, the Italians are now constructing wharves protected by outer works, which, it is reported, will be ready for use in 1940 by vessels up to 10,000 tons. Other sites on the coast are being examined by the Italian Government with a view to the construction of harbour works on a modest scale. Among these are Mogadishu, an open roadstead in Somaliland, and Chisimaio, near the Kenya frontier.

It is reported that the Portuguese Government proposes to modernise and improve the natural harbour of St. Paul de Loanda, which is the principal port of Angola.

(To be continued)

Oil-Engined Rail Traction in 1938

No. II

(Continued from page 16, January 6th)

The Birmingham Railway Carriage and Wagon Company, Ltd.

MANY railcars have been shipped in the past by the Birmingham Railway Carriage and Wagon Company, Ltd., of Smethwick, for service on South American Railways. In our review last year we illustrated and described the vehicles made for the Central Argentine Railway; other cars are in service on the Buenos Aires Pacific, the Entre Rios, and the Buenos Aires Western Railways. The latest order, which was in course of delivery towards the end of 1938, is for ten twin-car sets for the Buenos Aires Midland Railway, a 320-mile metre-gauge undertaking operated jointly by the B.A.G.S. and the B.A.W. railways. The new articulated design, of which a view is reproduced in Fig. 12 herewith, is propelled by two Gardner "6 LW" engines with a maximum output at top normal speed, 1700 r.p.m., of 102 B.H.P. each. Over the full working range of speed and power the fuel consumption is said to be below 0·4 lb. per B.H.P. hour. Power is transmitted through Vulcan-Sinclair fluid couplings and Wilson gearboxes to spiral bevel reverse gears and final drives of David Brown manufacture. At maximum

engine revolutions the speed of the cars is about 55 m.p.h.

According to the body work, the gross weight of these twin units, with passengers and luggage, is about 36½ tons, or in the case of the vehicles designed for parcels and poultry traffic, about 45 tons. The weight of the local trains empty, but with fuel and water, &c., is 28¾ tons; the difference between empty and loaded weights for the different vehicles has necessitated different proportions for the springing systems. In the engraving reproduced in Fig. 13 is shown the welded steel construction of the bogies; the axle drive and reversing gear can be seen on the left-hand axle. Automatic vacuum brake equipment was supplied by G. D. Peters and Co., Ltd. The bodies and underframes were constructed separately by welding and were then riveted together.

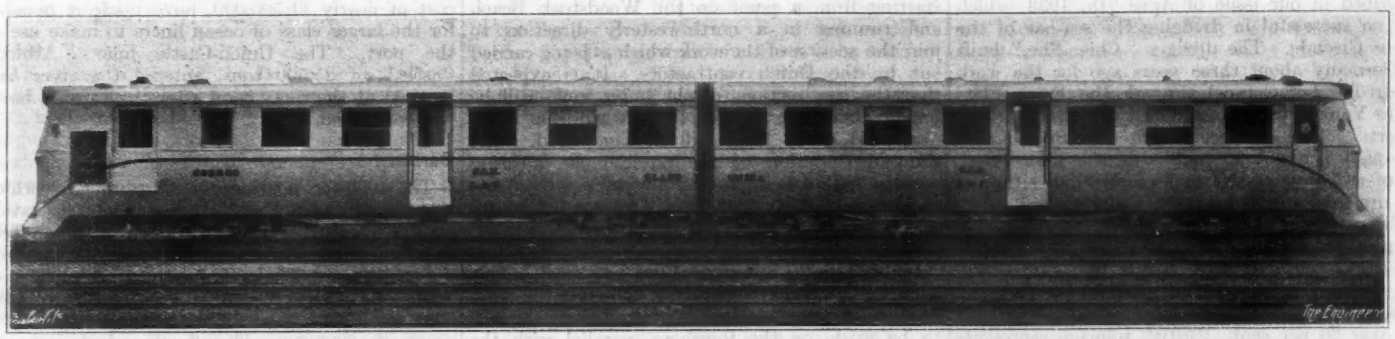


FIG. 12—ARTICULATED 102 H.P. RAILCARS FOR BUENOS AIRES MIDLAND RAILWAY—BIRMINGHAM RAILWAY CARRIAGE

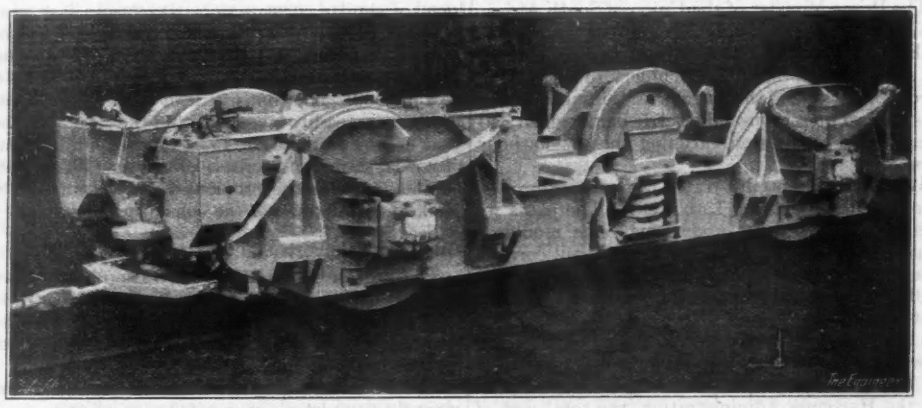


FIG. 13—POWER BOGIE OF ARTICULATED RAILCARS—BIRMINGHAM RAILWAY CARRIAGE

Leyland Motors, Ltd.

We referred in our article ast week to the L.M.S. three-car train, for which Leyland Motors, Ltd., supplied nine sets of power units. The transmission and control systems of this train are also of the company's design and manufacture. During the past year the company also constructed power and transmission units for railways in New South Wales, New Zealand, and for use with vehicles of the L.M.S. (N.C.C.) Railway Company, Ireland.

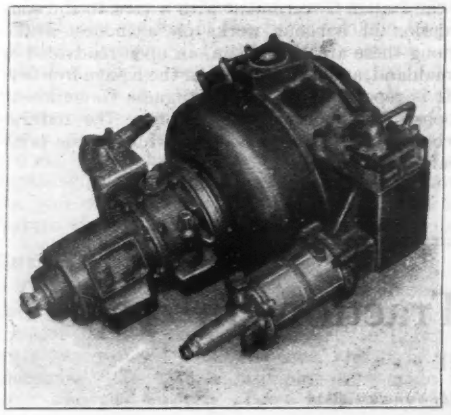


FIG. 14—TORQUE CONVERTER—LEYLAND

For the New South Wales Government Railway Company nine sets of six-cylinder 10-litre petrol engines, with bores and strokes of 4⅝in. and 6in., developing 140 B.H.P. at 2200 r.p.m., together with torque converters, control pedestals, and electro-pneumatic controls were constructed. These units were for fitting in twin-engined railcars designed and built by the railway company. The engines are mounted in the underframe, approximately in the middle of the car. Of standard Leyland (Lysholm Smith) type, the torque converter unit, illustrated in Fig. 14, has a totally enclosed clutch housing. Also mounted on the underframe are the radiators and a fan drive, taken from the front of the engine through spiral bevel gears and a short propeller shaft. The control of the torque converter and final drive is carried out in exactly the same manner as on the L.M.S. three-car train, and the system was fully described in our issue of April 8th, 1938, in an article dealing with the control system of that train. In Fig. 15 is shown the control box, housing electro-pneumatic valves, relays, and so forth.

Twelve sets of power units for twin-engined railcars, including all controls, were supplied for the New Plymouth section of the New Zealand Government Railways. They comprise six-cylinder 10-litre oil engines, with bores and strokes of 4⅝in. and 6in., developing 118 B.H.P. at 1900 r.p.m., fitted with C.A.V.-Bosch injection equipment. In these cars a complete engine and transmission set is mounted in each of the two bogies of the car. Transmission is through a torque converter and a vertically disposed double reduction final drive gear-box mounted directly on the driving axle. Controls follow similar lines to those described above. A special fan drive is taken from the front of the engine by V belts and a cardan shaft with six flexible Hardy Spicer couplings. A bevel drive gear-box drives the fan, and also, through V belts, the main compressor. In Fig. 17 a final drive gear-box for one of these vehicles is illustrated.

For the L.M.S. (N.C.C.) Railway Company, Ireland, No. 4 railcar two sets of engine-transmission-control equipment, comprising standard Leyland equipments, similar to those described above were constructed. This vehicle is a twin-engined car with a final drive consisting of a Leyland horizontal double reduction gear-box. Controls for the torque converter and final drive are of the electro-vacuum type, and are similar to those supplied to the L.M.S. Railway, except that vacuum is used in place of compressed air. The fuel control is hydraulically operated, by the "Exactor" system.

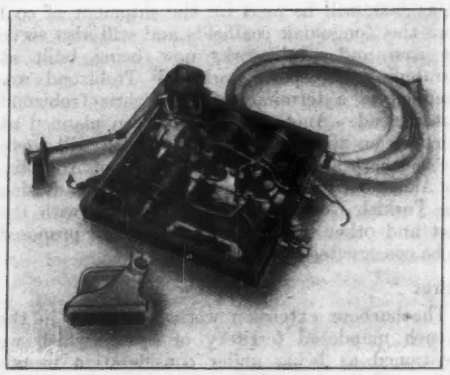


FIG. 15—CONTROL BOX—LEYLAND

On the Masterton section of the New Zealand Government Railways it has been decided to convert the petrol-engined railcars made in 1936, of

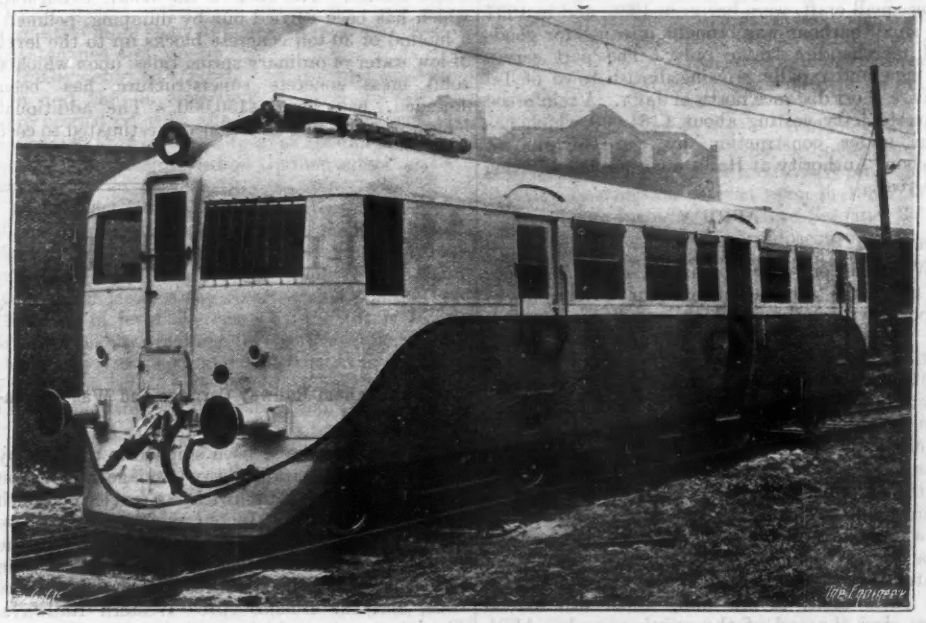


FIG. 16—102 H.P. RAILCAR FOR SOUTH AMERICA—DREWRY

which the engines were of Leyland manufacture, to oil-engined vehicles, and to fit the existing petrol engines in shunting locomotives. For this conversion seven oil engines of the type described

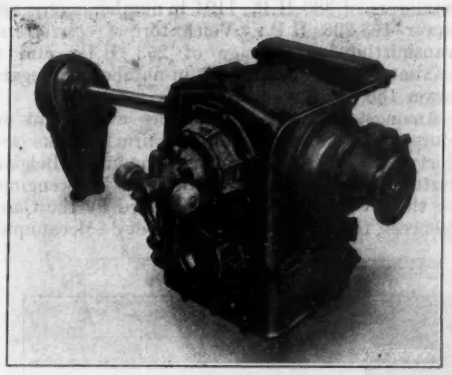


FIG. 17—FINAL DRIVE GEARBOX—LEYLAND

above are being manufactured at Leyland, but no controls or transmission gears are being supplied, since the existing gears are suitable.

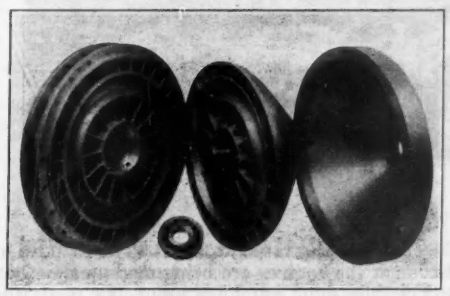


FIG. 18—FLUID COUPLING FOR 380 B.H.P. RAILCAR—HYDRAULIC COUPLING

Six 10-litre petrol engines and two 10-litre oil engines, together with torque converters, are on order for the New South Wales Government Railways, the controls for which are being designed and manufactured by the railway company.

The Drewry Car Company, Ltd.

In our issue of March 25th, 1938, there appeared a full illustrated description of the 107 railcars for service on the Buenos Aires Great Southern, the Buenos Aires Western, the Entre Rios, and the Argentine North-Eastern railways. As mentioned in the introduction, this large contract, held by the Drewry Car Company, Ltd., forms an example of standardised production. The consulting engineers for the contract are Messrs. Livesey and Henderson, and the vehicles were erected, or are in process of erection, at the Dick-Kerr works at Preston of the English Electric Company, Ltd. The major features of the cars, which to a great extent are alike, are shown in the two accompanying engravings, Figs. 16 and 19. In the first-named is shown a view of a complete 102 B.H.P. railcar, suitable for multiple-unit operation; the second engraving shows a sub-assembly of change-speed and reduction gear-boxes, together with their operating cylinders and electro-magnetic control valves. Motive power is furnished by a Gardner "6 LW" oil engine, developing 102 B.H.P. at 1700 r.p.m., and thence the power is taken through a Vulcan-Sinclair fluid coupling to a Wilson-Drewry four-speed epicyclic gear-box. The complete power and transmission system is

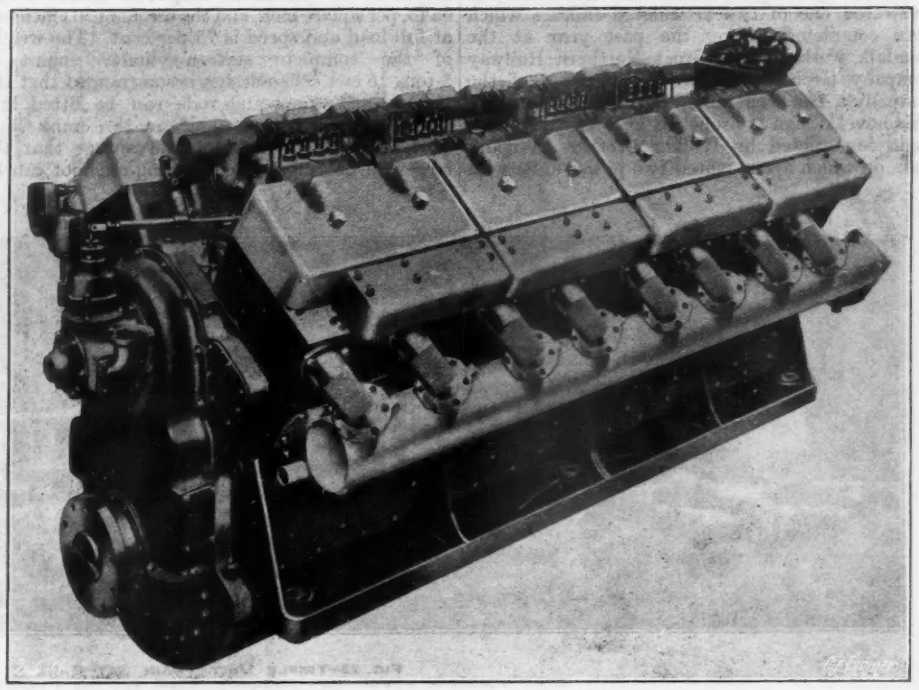


FIG. 21—1000 B.H.P. SIXTEEN-CYLINDER OIL ENGINE—PAXMAN

mounted on one of the two bogies. Ninety-nine of these vehicles are for the B.A.G.S. and B.A.W. railways' 5ft. 6in. gauge systems, and all the power bogies are interchangeable for this portion of the contract; second-class passenger cars of this type have a tare weight in running order of 22 tons 5 cwt. The remaining cars are for standard 4ft. 8½in. gauge. The coaches are of the same general construction throughout, the bodies and underframes

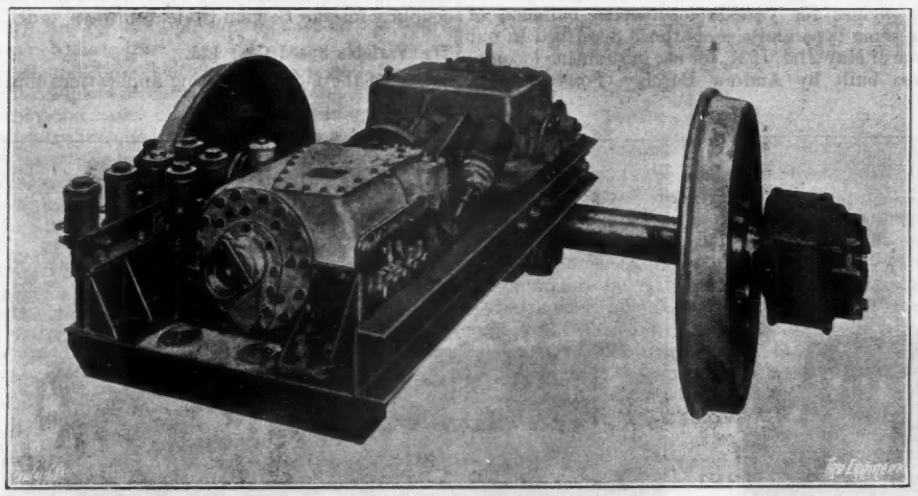


FIG. 19—CHANGE SPEED AND REDUCTION GEARBOXES OF 102 B.H.P. RAILCAR—DREWRY

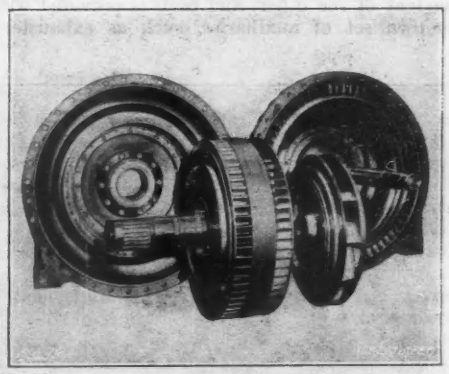


FIG. 22—TORQUE CONVERTER—VARIABLE SPEED GEAR

being built integrally and assembled by welding. Driving positions are provided at both ends of all the cars and a central door and hinged fall plate is arranged in each end of the body, to enable the train staff to pass from end to end of a two or three-car rake, when operating in multiple.

Other orders received by the Drewry Car Company, Ltd., upon which work is in an advanced stage, are for four railcars, fitted with double

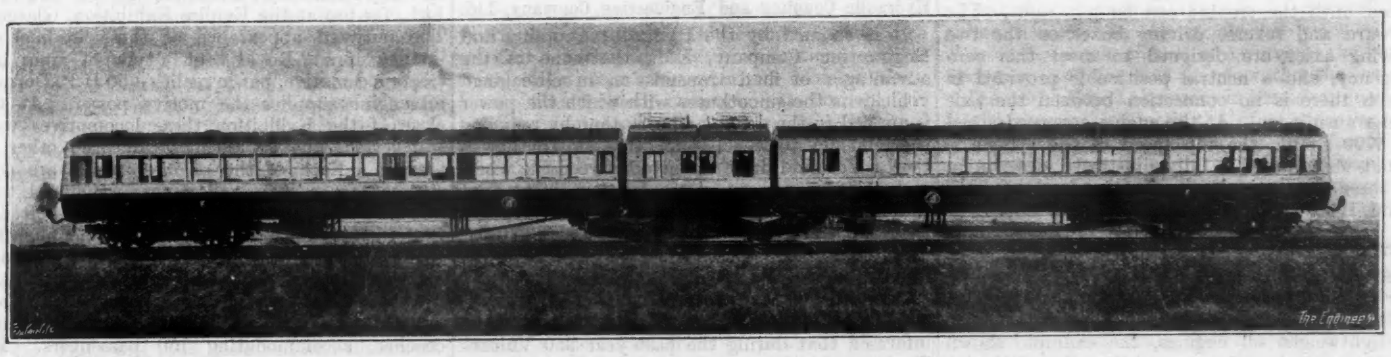


FIG. 20—204 B.H.P. ARTICULATED RAILCAR—WALKER

power bogies and engines of 102 B.H.P. each for the Nizam of Hyderabad, repeat orders for seven locomotives for service in New Zealand, and many other overseas orders for shunting locomotives, trollies, tractors and so forth.

Walker Brothers (Wigan) Ltd.

In the engraving reproduced in Fig. 20 there is illustrated one of two articulated railcars which were completed during the past year at the Dundalk works of the Great Northern Railway Company (Ireland), under the direction of the company's chief engineer, Mr. G. B. Howden. This novel design is propelled by a central power bogie constructed by Walker Brothers (Wigan), Ltd., on which are mounted two power units with sixteen-cylinder unit which develops 1000 B.H.P. at a maximum speed of 1750 r.p.m. The cylinders are arranged in two banks set at 60 deg., forming a particularly compact design with a high power-to weight ratio. The range consists of eight, twelve, and sixteen-cylinder engines, with bores and strokes of 7in. and 7¾in., respectively. The B.M.E.P. at maximum output is stated to be 95 lb. per square inch, and the mechanical efficiency at full load and speed is 75 per cent. The weight of the complete sixteen-cylinder engine is 3 tons 15 cwt. The design is so arranged that the pistons and connecting-rods can be fitted and removed through large doors in the crank case. This arrangement gives the advantage that the large end bearing and connecting-rod foot can be made of ample dimensions, since it is not necessary for them to pass through the cylinder bore. The cylinder heads are cast in pairs, four pairs being bolted on to each bank of cylinders, and the combustion chambers are designed on the well-known Ricardo Mark III principles. Four fuel pumps of C.A.V.-Bosch manufacture, driven in line between the cylinder banks, are used.

Other productions of the company during the past year included a number of eight-cylinder oil engines for various locomotive builders, of the same type and size as those described in our issue of May 21st, 1937, for use in shunting locomotives built by Andrew Barclay, Sons and Co. Ltd., the Hunslet Engine Company, and Hudswell, Clarke and Co., Ltd.

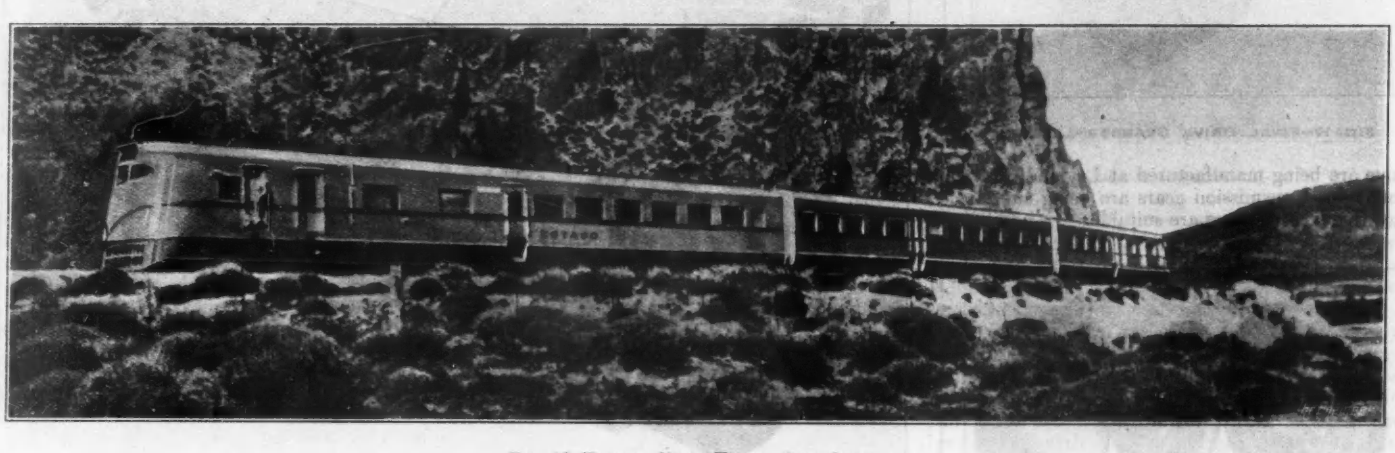


FIG. 23—TRIPLE UNIT TRAIN SET—GANZ

independent drives to each of the two axles. The trains therefore consist, as shown in the engraving, of three-car articulated rakes, in which the short central units form power carriages only, and the end units are for passenger accommodation. Each power and transmission set comprises a Gardner 6 L W engine with a maximum output of 102 B.H.P., a Vulcan-Sinclair hydraulic coupling, a Wilson five-speed epicyclic gear-box, Layrub propeller shaft, and a Walker spiral bevel forward and reverse gear-box, mounted on the axle. Since each power unit is entirely independent of the other, and each is provided with its own set of auxiliaries, such as exhausters, train-lighting equipment, and oil cooler, a failure occurring in one engine or its transmission will not prevent the train being driven at a reduced speed until the trouble can be put right. The forward and reverse driving boxes on the two driving axles are designed to meet this contingency, and a neutral position is provided in which there is no connection between the axle and transmission. At the engine governed speed of 1700 r.p.m., the top speed of the vehicle is about 48 m.p.h. A fully illustrated description of these cars was published in our issue of April 22nd, 1938.

Davey, Paxman and Co. (Colchester) Ltd.

A new engine, suitable for use in railcars and for other applications, was described in THE ENGINEER of July 22nd, 1938. Typical of a range of lightweight oil engines, the example shown in the accompanying engraving, Fig. 21, is a

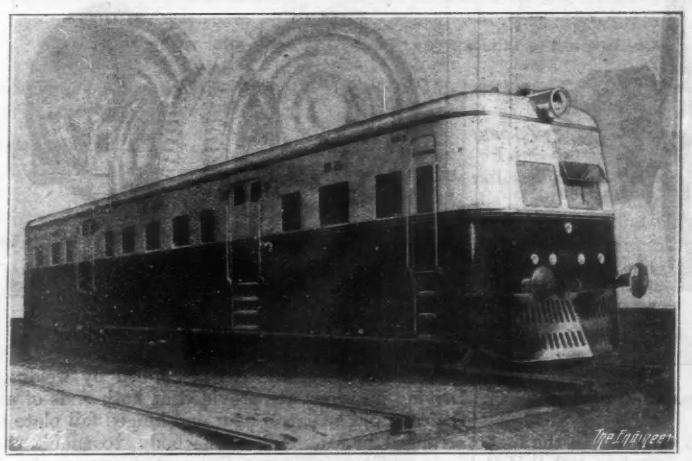


FIG. 24—235/275 H.P. RAILCAR FOR INDIA—GANZ

FIG. 25—POWER BOGIE OF RAILCAR FOR INDIA—GANZ

Hydraulic Coupling and Engineering Company, Ltd.

It is claimed by the Hydraulic Coupling and Engineering Company, Ltd., that one of the advantages of fluid transmission in oil-engined vehicles is the smoothness with which the power is applied to the driving wheels, thereby reducing the tendency to wheel spin. It is stated that in the case of fluid drive the grip between the wheel and rail depends on static friction, instead of sliding friction, as when wheel spin occurs, and that the tractive effort on wet rails is 20 per cent. greater than with a friction-drive locomotive of equal power, weight, and gear ratio.

The company is, of course, the manufacturer of Vulcan-Sinclair fluid couplings. We are informed that during the past year 350 Vulcan-Sinclair couplings, aggregating 46,172 H.P., and 337 Voith-system torque converters, aggregating 69,695 H.P., were ordered. These orders make the total numbers in use in the world at December 31st, 1938, as follows:—Vulcan-Sinclair couplings, transmitting an average of 138 H.P., and a maximum of 380 H.P., 1194 in number, aggregate power 165,298 H.P.; Voith torque converters, transmitting an average of 253 H.P., and a maximum of 1380 H.P., 665 in number, aggregate power 168,725 H.P.

Amongst the principal orders at present in course of construction at the firm's works are thirty-seven fluid couplings for the Belgian State Railways for new railcars. The engines for these vehicles are being supplied by the Ganz licencees, the Société d'Electricité et de Mecanique, the engines being rated at 380 H.P. at 1330 r.p.m. Although the engines are being made under Ganz licence, the fluid couplings are being used with S.L.M. gear-boxes, instead of the standard Ganz friction clutch and mechanical gear. Also, twenty-three Voith torque converter transmissions of 360 H.P. are being supplied for oil-engined locomotives, four of which are for Friedrich Krupp A.G. at Essen. The accompanying engraving, Fig. 18, illustrates a Vulcan-Sinclair fluid coupling for the Belgian State Railways' order.

The Variable Speed Gear Ltd.

One of the most interesting applications during the year of fluid torque converters lay in the transmission system of the narrow-gauge locomotives specially built by Hudswell, Clarke and Co., Ltd., for use at the Empire Exhibition, Glasgow. The outward appearance of these locomotives is that of a "Royal Scot" type of main line steam locomotive, but in reality a 50 H.P. Dorman oil engine supplies the motive power. At the close of the Exhibition these locomotives were transferred, one to Skegness and the other to Clacton. Each of the engines, which are constructed for a 21in. rail gauge, weighs 14 tons and has a length over engine and tender of 30ft. 6in. Power is transmitted from the oil engine, mounted inside the "fire-box," through a V.S.G. Lysholm-Smith fluid torque converter to a forward and reverse gear on a leading driving axle. Each locomotive is capable of hauling a train of five coaches, accommodating 150 passengers. For such duties as at exhibitions, &c., an oil-engined

locomotive was thought to be preferable to a steam locomotive, by reason of the need for instant availability. Further, a fluid torque converter possesses characteristics analogous to those of a steam engine drive, and its introduction into the transmission of an oil-engined locomotive dispenses with the use of a mechanical gear-box, making it very suitable for the purpose described above. In an accompanying engraving, Fig. 22, we illustrate the internal parts of such a torque converter.

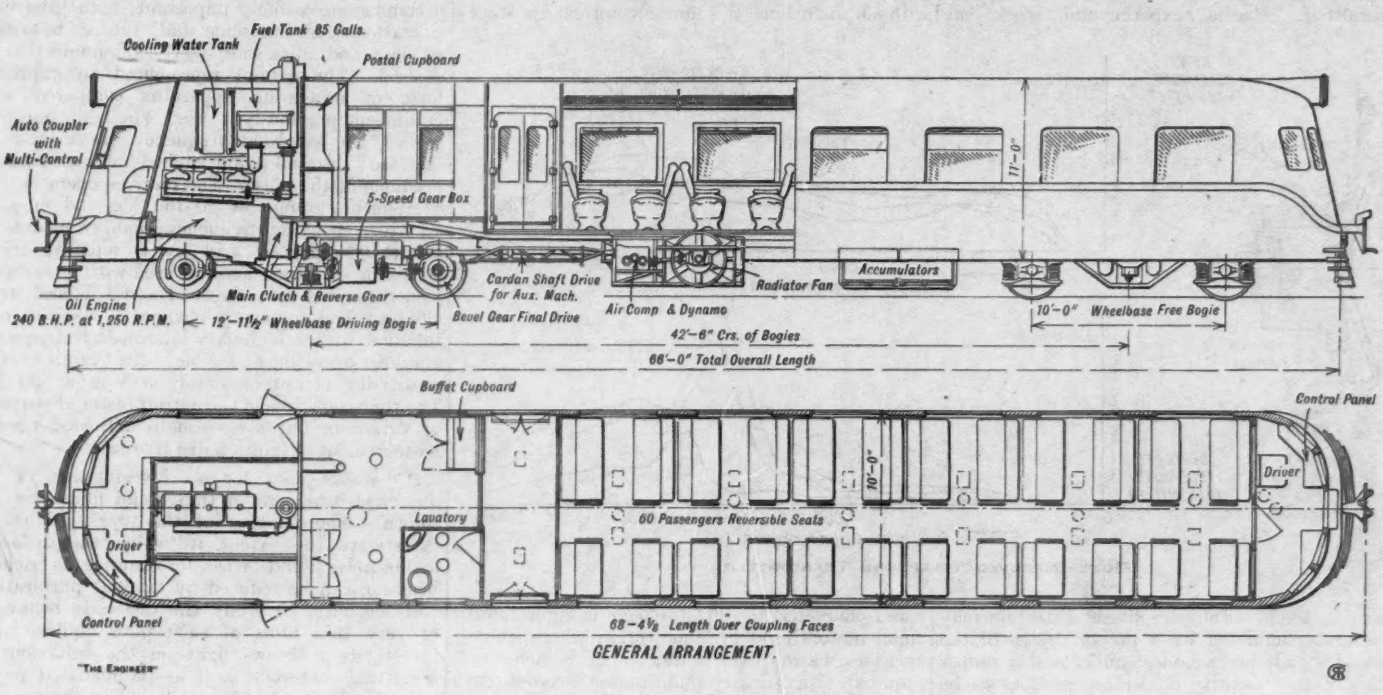


FIG. 26—ARRANGEMENT OF 240 B.H.P. RAILCAR FOR SOUTH AMERICA—GANZ

PRODUCTION ABROAD

Hungary

No fewer than eighty-one railcar units, many of which are for multiple-unit operation, six spare power bogies, thirty-five oil engines for use as spares and for oil-electric vehicles, and twenty-eight complete mechanical equipments, of which in twenty-one cases oil engines and design of car bodies are included, were supplied in the course of the year 1938 by the well-known Hungarian firm, Ganz and Co. These vehicles and accessories are in service in all parts of the world.

In South America, the Argentine State Railways took delivery of two triple-unit train sets, each consisting of two power railcars and one trailer vehicle. They are fitted with two 310/350 H.P. Ganz engines, giving an aggregate maximum power of 700 H.P.; an illustration of one of these trains is reproduced in Fig. 23 herewith. In addition to this order the firm supplied twenty-eight eight-wheeled oil-engined railcars with 235/275 H.P. engines and two other twin-engined triple-car trains for service on this railway system. For the Uruguayan State Railways ten railcars and ten fourteen-wheeled articulated sets were delivered.

For use on the North-Western Railway of India eleven eight-wheeled railcars with engines developing 235/275 H.P. were shipped. These vehicles are illustrated in Fig. 24 and one of the power bogies is shown in Fig. 25.

In addition to the above orders completed there were substantial deliveries to the Jugoslavian State Railways, the Egyptian State Railways, the Calea Ferata Romana, the Royal Hungarian State Railways, and the Budapest Local Railways. In the case of the Jugoslavian State Railways the equipments supplied consisted of complete mechanical parts, 230/290 H.P. oil engines, and the design of car bodies for seven three-car trains, each consisting of two power railcars and one trailer. For the Calea Ferata Romana complete mechanical equipments were also supplied, for a four-unit State railcar train, driven by oil engines with a total of 880 H.P., and for three eight-wheeled 235/275 H.P. railcars.

A design of railcar for multiple-unit operation on the Buenos Aires Pacific Railway Company's system, which was the result of collaboration between the chief mechanical engineer of the railway company, Mr. R. E. Kimberley, and Ganz and Co., Ltd., was fully described and illustrated in our issue of February 18th, 1938. In the accompanying engraving, Fig. 26, are shown general arrangement views of one of these units. These cars were designed for long-distance main line service. Six vehicles in all were ordered and constructed in the workshops of the railway company in Argentina. Three of the cars were fitted with mechanical transmission, consisting of a Ganz five-speed gear-box with the drive taken to the two axles of the power bogie, and the remaining three were fitted with Voith-Sinclair turbo-transmission, with the drive on one axle of the power bogie. All six vehicles, however, were fitted, for reasons of interchangeability, with standard Ganz six-cylinder oil engines, each developing 240 B.H.P. at 1250 r.p.m. The laden weight of each unit is about 40 tons, and the maximum speed 100 kiloms. per hour. In the article referred to above the automatic couplings and "jumper" connections for multiple unit operation were fully described and an interesting account of some of the trial runs was given.

(To be continued)

The Physical Society's Exhibition

No. II

(Continued from page 18, January 6th)

THE exhibits of the National Physical Laboratory demonstrated the work done by the physics department in radiology, acoustics, temperature measurement, and heat. In the radiology section there was an exhibit which demonstrated by transparencies and illuminated crystal models how X-ray crystal analysis is used in investigations into the structure of materials a knowledge of which is valuable for many purposes, such, for example, as the assessment of the effect of heat treatment or mechanical work.

The methods used at the N.P.L. for the measurement and analysis of noise were demonstrated, whilst models were designed to show the solutions which have been arrived at in the investigation of sundry noise problems. The principle of an elastic support with a low natural period has been found to be effective both for the insulation of machinery and for the reduction of the transmission of impact noise such as footsteps.

Demonstration of the instrumental technique employed showed the use of noise meters for the determination of the overall equivalent loudness of noises, an apparatus for the instantaneous analysis of noise and a cathode-ray oscillograph for recording wave form of sounds of a steady or fluctuating character. This equipment has been used for a variety of noise investigations, such as those relating to machinery, motor vehicles, motor horns, underground railways, gas burners, air raid warning devices, &c. A portable type of noise meter, designed for the Ministry of Transport for routine measurements of road noises, was also exhibited.

Temperature measurement was represented by a comprehensive exhibit showing the work of the Laboratory in maintaining the International temperature scale and in standardising instruments of the liquid-in-glass electrical resistance, thermo-couple, and optical types. A photograph showed a specialised form of platinum thermo-couple mounting developed at the Laboratory and used with success for the measurement of molten steel temperatures.

Apparatus used for the measurement of flame temperatures by the spectral line reversal method was to be seen in operation. The flame under investigation is charged with a sodium salt, and the D lines are observed in a spectroscope. Behind the flame is a tungsten arc lamp, and the temperature of this is raised until the D lines are at the point of reversal. The apparent temperature of the tungsten arc is observed by means of an optical pyrometer, and has been shown to be an accurate measure of the flame temperature.

A simple and convenient apparatus for the standardisation of thermo-couples at sulphur boiling point was shown in operation. Various difficulties have been overcome by the use of an immersion heater, and the apparatus can be used in an open laboratory without inconvenience from fumes. A demonstration was given of the method used at the N.P.L. for the determination of the ratio of the specific heats of gases at temperatures as high as 1800 deg. Cent. The method used is to determine the velocity of sound in the gas by means of a Kundt's tube. The formation of stationary waves in the tube is detected by observation of the abrupt change which takes place in the anode current of a valve in the high-frequency oscillator used for generating the sound.

The work of the Laboratory in the determination of the thermal conductivities of a wide variety of substances was indicated by two forms of apparatus. One is used for investigations on mica, while the other is a guard-ring apparatus for general use with hot-plate temperatures ranging from 100 deg. to 500 deg. Cent.

Of the Post Office research station's exhibits, that relating to the newly designed inset for subscribers' telephone transmitters was of the greatest general interest. The apparatus shown was designed to demonstrate the reduction in amplitude distortion and the improvement in frequency

response. It is well known that the sensitivity of an ordinary subscriber's telephone transmitter is largely controlled by the intensity of the sound to which it is exposed. Over a wide range of sound pressures the sensitivity of the instrument increases with increasing sound pressure to an extent which is sufficient to introduce serious distortion of speech transmitted. Recent experimental work has shown that this serious amplitude distortion may be almost eliminated by a proper design of the electrodes and the carbon chamber and a proper choice of the quantity of carbon granules to be used in the transmitter. The general object of the design is to allow the granules a considerable freedom of motion, and to encourage them to separate from one another during the operation of the transmitter. The demonstration was arranged to show that the sensitivity of an instrument designed on these lines is almost independent of the applied sound pressure. The inferior performance of a standard telephone transmitter in this respect was also demonstrated. The new design of transmitter includes an acoustical device, which has the effect of equalising the frequency/response characteristic of the instrument so that the sensitivity is reasonably constant over the frequency range 300–2800 c.p.s. This feature was also demonstrated, the frequency characteristic of the new type transmitter being compared with that of the present standard instrument. A section of the new instrument is given in Fig. 9, which also indicates the reduction in amplitude distortion and improvement in frequency response of the new transmitter. The theory involved is dealt with fully by Mr. D. McMillan in the *Post Office Electrical Engineers Journal* of October, 1938.

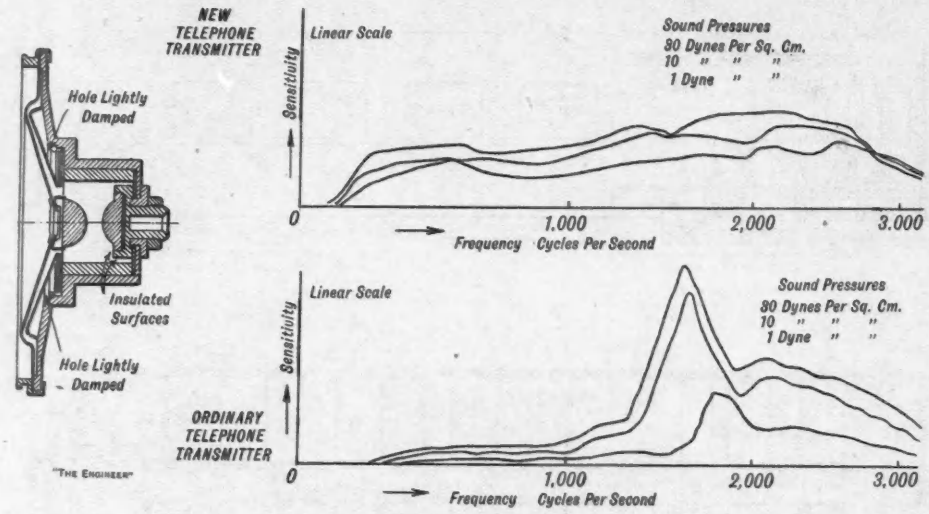


FIG. 9—IMPROVED TELEPHONE TRANSMITTER

One of the exhibits of Dr. Otto H. Schmitt, of the Department of Biophysics of the University College, London, was an electric motor circuit (Fig. 10), giving a wide range of speed control without disturbing the motor's normal constant-speed characteristic. The scheme is applicable to small motors used in laboratories, where smooth speed regulation over a wide range is sometimes required. An ordinary shunt motor is reconnected with its armature and field coils in series across the full mains potential. If operation in the original direction of rotation is required the field winding is reversed. As shown in Fig. 10, a point common to both armature and field is connected to the movable contact of an ordinary slide potentiometer, also connected across the mains. On moving the contact in one direction the field is strengthened and the armature voltage decreased. This produces a reduction in the available speed until at the extreme end of the potentiometer the speed falls to zero. By moving the potentiometer contact towards the opposite end the field is weakened and the armature voltage increased, giving a greatly increased speed. Either a stop should be fitted to the potentiometer near the high-speed end or a small permanent resistance should be incorporated; otherwise the armature speed may become excessive. Care has also to be taken to see that the movable contact is not left too long at the zero speed position, as the field may be overheated. For the best operation the potentiometer should have the same total resistance as that of the motor when operating normally at full load. For all small 200–250-volt mains-operated motors a 300-ohm unit will give satisfactory results, but should be constructed to carry at least 1·5 amperes. Although this method of speed control is wasteful, it is permissible for small machines. Stable operation is obtained over a ratio of speeds of 100 to 1 in a range from 1 revolution per second to 6000 r.p.m. The scheme was described by Dr. Otto Schmitt in the September issue of *The Journal of Scientific Instruments*.

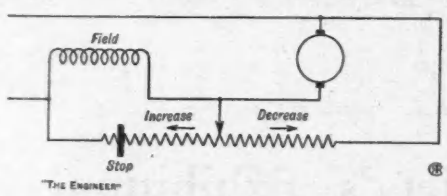


FIG. 10—VARIABLE SPEED MOTOR CIRCUIT

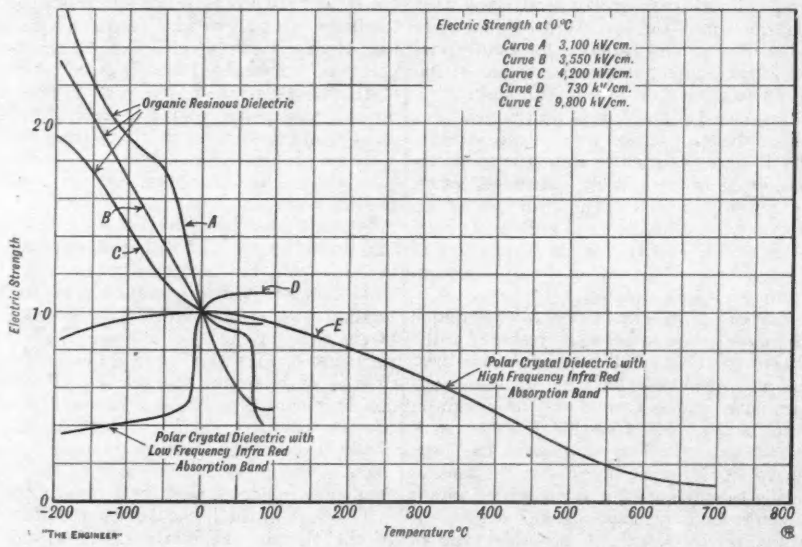


FIG. 11—VARIATION OF INTRINSIC ELECTRIC STRENGTH

An ultra-high-frequency receiver for the measurement of radiated electrical interference was one of the exhibits of the British Electrical and Allied Industries' Research Association. The necessity for the suppression of ignition interference is becoming increasingly important, both from considerations of present and future television services and ultra-short-wave communication in general. The exhibit represented an improved form of measuring apparatus compared with equipment previously in use. The main improvements are extended frequency range and an increased discrimination against inter-modulation products of the noise. The receiver operates over a frequency range of 20–100 Mc and employs an acorn pentode frequency changer modulated *viâ* the suppressor grid by a separate triode oscillator. A dipole aerial is used with an untuned feeder coupled to a screened and balanced input circuit. The frequency changer is used in conjunction with a high-gain intermediate frequency amplifier operating at 1·6 Mc. The overall limiting sensitivity is approximately 3 V/m at 90 Mc. The time constants of the output meter are capable of variation, but are normally adjusted for the measurement of ignition disturbance.

Apparatus used for an investigation of the dielectric behaviour of thin liquid films was also shown. The purpose of this work is first to investigate the extent to which the dielectric loss of polar liquids, such, for example, as trichlorbenzene, can be reduced by extreme purification, and secondly, to study the dielectric behaviour of very thin films of such pure liquids. The investigation throws light on the behaviour of insulating materials such as impregnated paper, which contain thin films of liquid in the pores of the material. The apparatus developed for the work permits the liquid to be purified by continuous distillation *in vacuo*. The liquid circulates continuously through purifying reagents, through the measuring electrodes, and then returns to the boiler for redistillation. When once evacuated the apparatus can be entirely isolated from all external contamination by mercury seals, so that if the impurity initially present in the liquid can be absorbed by reagents placed within the apparatus, the liquid will become and remain pure to a far higher degree than can be obtained by ordinary chemical technique. To avoid contamination from the materials of the apparatus itself, only Pyrex glass and stainless steel are used in its construction. With the apparatus it has been found possible to reduce the dielectric loss of polar liquids to less than one-tenth of their normal values. It is thought that with sufficient precautions a still higher degree of purity could be reached.

When the film of liquid between the electrodes is sufficiently thin, *i.e.*, the spacing of the electrodes is sufficiently close, for the ions in the liquid to be drawn completely across the gap by the action of the applied alternating field, in less than one-half cycle, a new effect becomes observable, the dielectric loss angle becoming a function of the applied field. The electrode separation necessary to observe this effect is, for most liquids, in the neighbourhood of 0·001in. The difficulty of working with such extremely thin films of liquid will be realised when it is remembered that very thin films of oil or grease, so far from being insulators, are actually used to improve contact between the surfaces of switches. But, by careful exclusion of all conducting particles, it has been possible to apply a stress up to 3 kV per millimetre on a film only 0·03 mm. thick, without breakdown.

The results obtained throw new light on the behaviour of impregnated porous dielectrics, and provide a new means of calculating ionic concentration and mobility from the experimental data.

Another of the Association's exhibits consisted of apparatus for the determination of the intrinsic electric strength of dielectrics at low, normal, and high temperatures. Determinations of the intrinsic or true electric strength of dielectrics are being carried out by the Association in connection with investigations of fundamental theories of breakdown. When a wide range of temperature is involved it is difficult to avoid deleterious action by the surrounding medium and of discharges therein. To overcome this difficulty samples with spherical-shaped recesses are employed. Specially designed tools which enable a recess to be ground in a sheet of dielectric of thickness of about 0·03 cm., leaving a thickness of 0·002 cm. at the base of the recess, were shown. In the case of films of organic substances, the sample is

prepared on tin foil in which spherical recesses have previously been pressed. When tested by these means over ranges of temperature which extend from —200 deg. Cent. up to the limiting temperature of the material, different substances

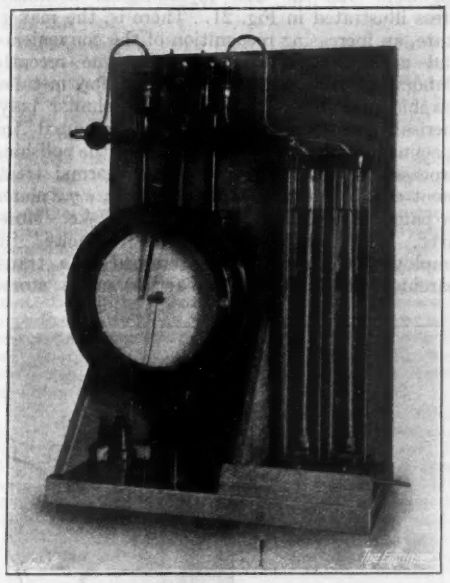


FIG. 12—SPECIFIC GRAVITY RECORDER—KENT

show, as indicated in Fig. 11, very different types of variation which are not perceptible over the small range of normal temperatures. Tests on two types of polar crystals have been made with

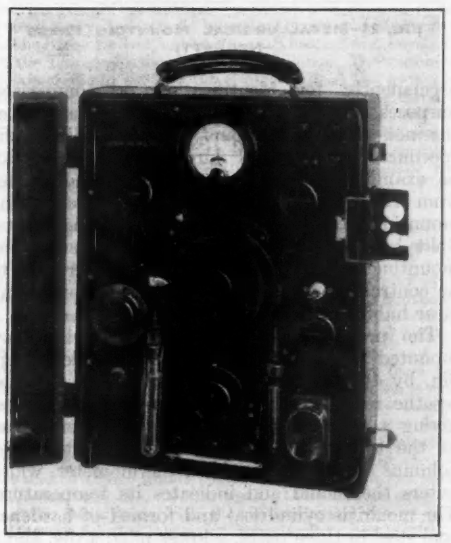


FIG. 13—PORTABLE PH POTENTIOMETER—KENT

a view to checking a recent theory of electric strength according to which the variation with temperature depends to some extent on the natural vibrational frequency of the lattice, as determined by the infra red absorption band. The exhibit included the Dewar flask used for the low-temperature tests. This is of special design, made for the purpose at the research laboratories of the General Electric Company, Ltd., and it has a wire sealed in at the base through both walls. Liquid nitrogen is used as refrigerant.

A new specific gravity recorder (Fig. 12) was one of the exhibits of George Kent and Co., of Luton. It uses a differential pressure meter connected to a patented arrangement of comparator tubes. The measuring device consists principally of two vertical tubes, one containing the standard liquid and the other the liquid of which the varying specific gravity is to be recorded. The differential pressure resulting from these two columns of equal height, but unequal density, is transmitted

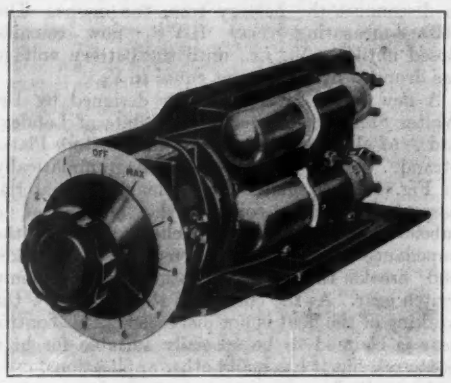


FIG. 15—"SIMMERSTAT" CONTROL APPARATUS—SUNVIC

by air reaction to the U tube of a standard differential meter. A continuous record of the specific gravity is thus obtained on a 12in. diameter circular chart which can be adjusted to rotate either once in a day or once a week. Owing to the patented principle of using the difference between two columns, the chart begins at one or other convenient figure instead of at zero, thus giving greatly increased accuracy.

The portable pH potentiometer shown in Figs. 13 and 14 was another George Kent exhibit. The instrument is self-contained in a 12in. by 16in. by

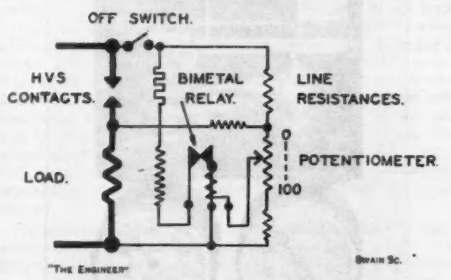


FIG. 16—"SIMMERSTAT" CONTROL CIRCUIT—SUNVIC

6in. aluminium case, which acts as an effective screen for the circuit incorporating a two-valve Wheatstone bridge network (Fig. 14), together with an accurate potentiometer, standardised against a standard Weston cell. The accuracy is independent of the valve characteristics. Current for the valves and filaments is supplied by a long-life dry battery. All measurements are made with reference to the micro-ammeter shown at the top of Fig. 13. The electrodes are to be seen in the lower part of this illustration, clamped in the normal position for carrying. One consists of a high-resistance glass electrode with a platinum electrode inside dipping into a solution of deci-normal hydrochloric acid saturated with quinhydrone. The other electrode is a standard calomel electrode with a potassium chloride salt bridge. When

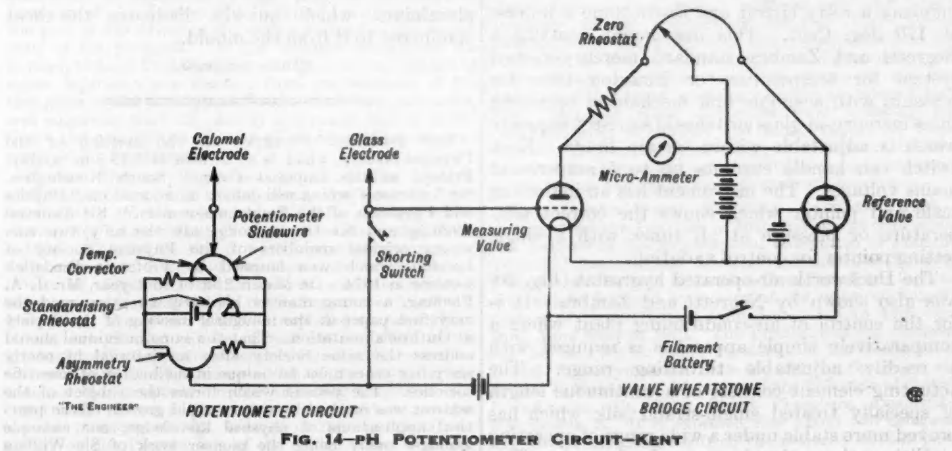


FIG. 14—PH POTENTIOMETER CIRCUIT—KENT

making tests, these electrodes are removed and inserted together with a thermometer in a holder on the right-hand side of the instrument. The centre rotating dial is marked off from 0 to 12 pH and from 0–780 millivolts. Directly above this dial is a scale with a setting device for automatic temperature compensation. A measurement is made by rotating the central disc until there is no deflection on the micro-ammeter and then reading off the pH value on the engraved scale. The micro-ammeter is a pivoted instrument, and although it is highly sensitive, it is robust and requires no clamping device.

On one side of the pH potentiometer is a multiple switch. When this is turned to the standardising position the potentiometer circuit can be standardised by the appropriate rheostat. Any potential from

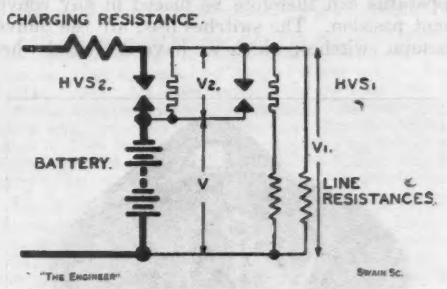


FIG. 17—CIRCUIT OF BATTERY TRICKLE CHARGE RELAY—SUNVIC

0 to 780 millivolts can be measured on the normal potentiometer circuit by connecting it to two terminals at the right-hand top corner. There is a filament resistance to adjust the valve filament current, which has the correct value when the micro-ammeter is giving its maximum reading. The zero rheostat is used for making initial adjustments to balance the Wheatstone bridge network. A rheostat at the bottom of the case is used to correct the asymmetry potential of the glass electrode and is set with the aid of a standard buffer solution. At the bottom of the case are three terminals. One is used to connect the case to earth to improve the electrostatic shielding. The two other terminals are provided to enable an external battery to be used for supplying the

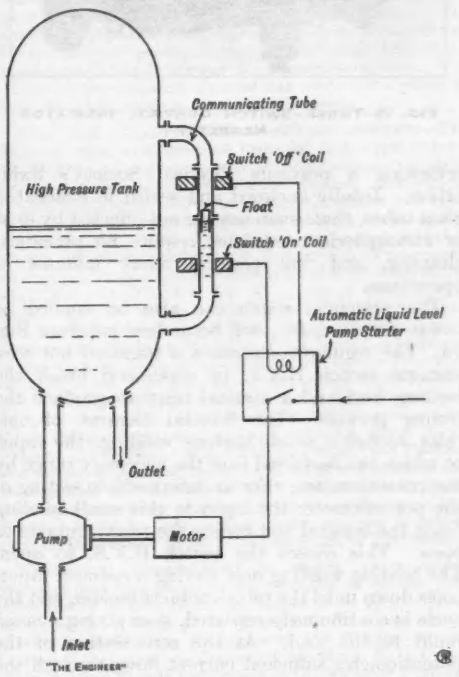


FIG. 18—LIQUID LEVEL CONTROLLER—LONDEX

filament current. Terminals marked "reference" and "glass" are connected to the electrodes. Finally there is a short-circuiting press button for eliminating the measuring circuit when obtaining an electrical balance on the Wheatstone bridge. The accuracy of the measurement is $\pm 0{\cdot}05$ pH or ± 2 millivolts.

An interesting device exhibited by Sunvic Controls, Ltd., of 1, Kingsway, W.C.2, was the Simmerstat control apparatus (Fig. 15) for cooker hot plates. A disadvantage that has seriously hindered the progress of electric cookers is that it has not been possible to adjust the heat available at the boiling rings continuously as with gas. To some extent the difficulty has been met by the provision of three or more heats, but the Simmerstat allows the input to a hot plate to be continuously adjusted from no load to full load by simply turning

a knob. While it has the same effect as the introduction of a series resistance, it involves no waste of power. The control is obtained by opening and closing the hot plate circuit for definite time intervals. Clearly the longer the time the circuit is switched "off," and the shorter the time it is "on," the smaller the average input to the hot plate and the lower its temperature. As the apparatus merely alters the average input on a time basis, it does not require any tappings on the hot plate, which may have a single circuit arranged for the full loading. Nor does it require a multiple heat switch. The apparatus will control any hot plate up to 2 kW, 230 volts, on A.C. or D.C., from no load to full load without any modification. The control does not involve any temperature sensitive device in contact with the hot plate and the apparatus can therefore be placed in any convenient position. The switches used are the Sunvic vacuum switches, which we have described when

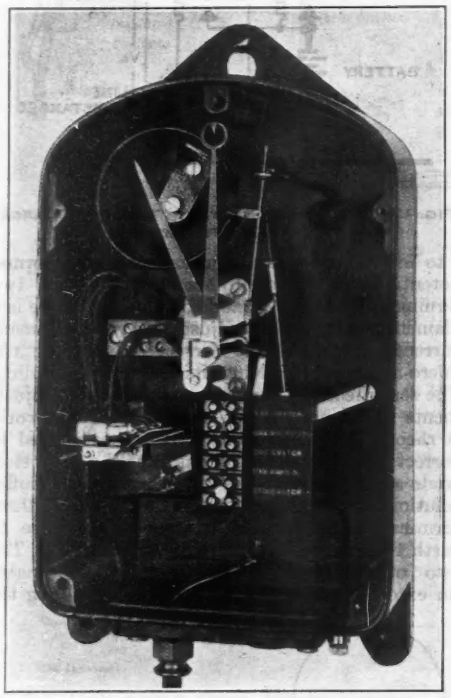


FIG. 19—THREE-SWITCH CONTROL INDICATOR —NEGRETTI

reviewing a previous Physical Society's Exhibition. Totally enclosed and sealed in evacuated glass tubes, these switches are not affected by dust or atmospheric conditions, require no periodical cleaning, and will perform many millions of operations.

The principle, which can also be applied to ovens, furnaces, &c., will be understood from Fig. 16. The regulator comprises a standard hot wire vacuum switch H.V.S. to make and break the heating load and a bimetal relay to produce the timing periods. The bimetal element of this relay carries a small heating winding, the input to which can be varied over the necessary range by the potentiometer. For an intermediate setting of the potentiometer the input to this small winding heats the bimetal and causes the relay contacts to open. This causes the switch H.V.S. to open. The heating winding now having a reduced input, cools down until the relay contacts reclose, and the cycle is continuously repeated, thus giving a mean input to the load. At the zero setting of the potentiometer sufficient current flows through the small heating winding to keep the relay contacts permanently open. The switch contacts therefore remain open and the load is permanently off. At the maximum setting of the potentiometer the current in the small winding is insufficient to open the contacts of the bimetal relay. The switch H.V.S. contacts therefore remain closed and the load is permanently on.

A battery trickle-charge relay was another exhibit on this firm's stand. The principle upon which it operates will be understood from the diagram, Fig. 17. For trickle charging it is necessary that there should be a more or less large difference between the voltage at which the relay cuts off the charging current and the voltage at which it remakes the circuit. Otherwise there is a tendency for the relay to hunt in consequence of the sudden fall in battery voltage when the mains are disconnected. In the relay shown a differential voltage up to about 12 volts, depending on the voltage of the battery to be charged, is provided. Two hot-wire vacuum switches are used. One, $H V S_1$, acts as a voltage-measuring relay, and the $H V S_2$ as a main switch to break the battery circuit. This switch has a 6–12-volt hot-wire winding. Assuming the battery is on charge, the switch $H V S_2$ is closed and $H V S_1$ open. If V_2 is the operating voltage of $H V S_2$, and V_1 that of $H V S_1$, then the measuring relay $H V S_1$ will close when the battery voltage $V=V_1+V_2$. The closing of the voltage-measuring relay $H V S_1$ short circuits the hot-wire winding of $H V S_2$, and so causes its contacts to open and to disconnect the battery from the mains. The voltage-measuring relay $H V S_1$ now remains closed until $V=V_1$, *i.e.*, until the battery voltage has dropped by an amount equal to V_2.

A new liquid level controller designed by Dr. Walter Stern was one of the exhibits of Londex, Ltd., of Brettenham House, Lancaster Place, Strand, W.C.2. It is shown diagrammatically in Fig. 18. A small float of magnetic material passes through a coil on the outside of a tube. When the float reaches the coil, the impedance changes and a sensitive relay makes and breaks the control contacts of the pump switch gear. As the current in the coils is low the working of the float is not disturbed. This control gear is claimed to be specially suitable for high pressures, but it has many other applications.

A simple three-step alarm or control instrument (Fig. 19) was shown by Negretti and Zambra,

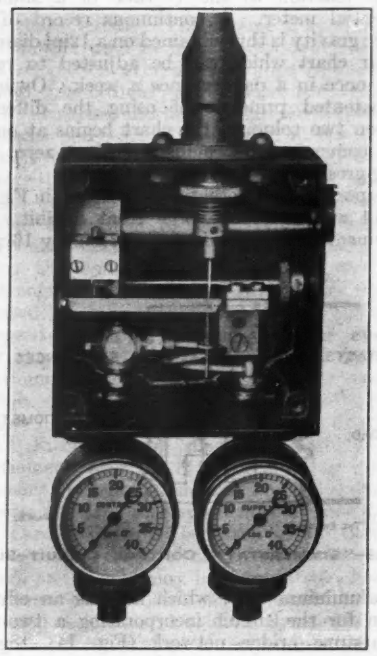


FIG. 20—AIR OPERATED HYGROSTAT—NEGRETTI

of 38, Holborn Viaduct, E.C.1. It is capable of taking care of three different temperature or pressure requirements with an interval between each. The first step may, for example, operate a preliminary warning light at 150 deg. Cent., the second may sound an audible warning at 160 deg. Cent., and the third may influence a relay circuit and discontinue a process at 170 deg. Cent. This instrument contains a Negretti and Zambra standard mercury-in-steel system for temperature or Bourdon tube for pressure with a simple link mechanism operating three mercury-in-glass switches in a pre-set sequence which is adjustable within certain limits. Each switch can handle currents up to 5 amperes at mains voltages. The instrument has an indicating scale and pointer which shows the correct temperature or pressure at all times with a single setting pointer for control variation.

The Duckworth air-operated hygrostat (Fig. 20) was also shown by Negretti and Zambra. It is for the control of air-conditioning plant where a comparatively simple apparatus is required with a readily adjustable throttling range. The actuating element consists of a continuous length of specially treated single-strand silk which has proved more stable under a wide range of operating conditions than other hygroscopic elements. This positions a large capacity pilot valve protected for overload conditions. The pilot valve governs the air supply to spray control valves or lever motors positioning dampers. The throttling range is adjustable from ½ to 5 per cent., or, alternatively, 1 to 10 per cent. by means of moving the pilot valve itself along the lever linked to the actuating element.

Several new products were shown by Griffin and Tatlock, Ltd., of Kemble Street, Kingsway, W.C., but perhaps the only one of real interest to engineers was the new metallurgical mounting press illustrated in Fig. 21. There is, the makers state, an increasing recognition of the convenience and usefulness of the new technique recently elaborated of mounting specimens for metallographic examination in bakelite or similar polymerisable thermoplastics. When mounted the specimen is much easier to hold during the polishing process. Specimens too small for normal treatment can be mounted and examined, *e.g.*, plated or painted sheets, fine wires, cuttings, &c. Moreover, when the thermoplastic "Lucite" is employed, the specimen is retained in a transparent, glass-like medium and can be stored

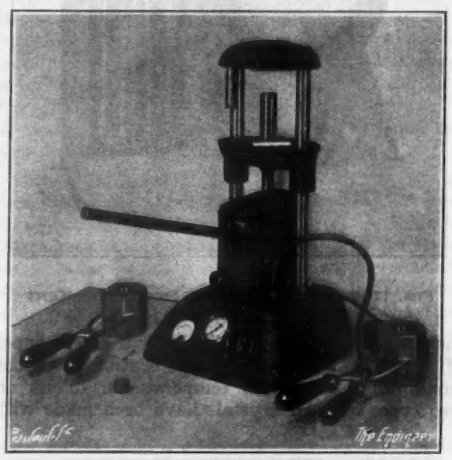


FIG. 21—METALLURGICAL MOUNTING PRESS —NEGRETTI

permanently for identification or comparison purposes. By reason of the close adherence of the non-shatterable mount to the medium, the specimen does not rock during polishing. It can be examined to the extreme edges, and is free from relief polish, margins, or crevices. The mounting medium is unaffected by etching agents. Split heating and cooling blocks accelerate the mounting process and enable the temperature to be controlled within the critical range, producing clear bubble-free mounts.

The press consists of a base on which are mounted two columns guiding a movable platen, 5in. by 4¾in., fitted with insulating plates, raised by the ram of a hand-operated hydraulic press giving a pressure up to 5000 lb. The crosshead at the top of the press is secured to the steel columns and bored to pass a thermometer, which enters the mould and indicates its temperature. The mould is cylindrical and formed of hardened tool steel in three parts, a lower plug, a die, and a plunger. An ejector piston attached to the crosshead, and a recess in the lower platen to receive the cylindrical mould, permit the mounted specimen to be ejected after forming. The heating block is of aluminium, split in the centre. Each half is fitted with an electric heating element, and is provided with handles. The cooling block is similar in design, but each half is of solid aluminium, which quickly dissipates the heat conducted to it from the mould.

(To be continued.)

THE PHYSICAL SOCIETY.—At the meeting of the Physical Society, which is to be held at 5.15 p.m. to-day, Friday, at the Imperial College, South Kensington, Sir Ambrose Fleming will deliver an address on "Physics and Physicists of the Eighteen-seventies." Sir Ambrose Fleming and Sir Oliver Lodge are the only two surviving original members of the Physical Society of London, which was founded by Professor Frederick Guthrie in 1874. On March 21st of that year, Mr. J. A. Fleming, a young man in his early twenties, read the very first paper at the inaugural meeting of the Society at Guthrie's invitation. That the same individual should address the same Society after an interval of nearly sixty-five years must be unique in the history of scientific societies. The decade which forms the subject of the address was marked by a very rapid growth of the practical applications of physical knowledge, one example amongst many being the pioneer work of Sir William Thomson (afterwards Lord Kelvin) on sensitive electrical instruments in connection with the first two Transatlantic cables for telegraphic communication between this country and the United States. The work for which Sir Ambrose Fleming himself is best known, namely, his pioneer work on the thermionic valve used in wireless telegraphy, belongs, of course, to a later period.

Rail and Road

PROPOSED NEW BRAZILIAN RAILWAY.—Reports state that plans have been prepared in Brazil for the construction of a 700 miles long railway between Barra do Pirai and Montes Claros, in the state of Minas Geraes. The line will take about five years to build, and it is planned to start work this year.

PROPOSED NEW ROAD IN AMERICA.—The New York City Park Commissioner has proposed that the recently abandoned right of way of the New York, Westchester, and Boston Railway should be converted into a toll trunk road to connect New York City with New England. The work entailed would cost about 32 million dollars.

FARES ON TASMANIAN RAILWAYS.—In the annual report of the Tasmanian Government Railways and Ferry Service, it is stated that for some time past consideration has been given to the desirability of introducing a one-class fare. The falling-off in passenger business, particularly in the first class, causes difficulty in the disposition of carriage stock, and an even greater difficulty arises in connection with the single-unit self-propelled cars. During the coming financial year it is proposed to experiment with a one-class fare, based on a 10 per cent. increase on the present second-class fare, with a reserved seat charge of 2s. to meet the requirements of those passengers desiring accommodation in what are at present first-class carriages.

RAILWAY TRAFFIC FIGURES.—According to official figures, the passenger journeys made during the first nine months of last year on British railways decreased by 8·3 per cent., and the tonnage of freight hauled decreased by over 23 million as compared with the same period in 1937. The figures show that during the period under review the number of passenger journeys, excluding season ticket holders, was 945,677,390, the receipts totalling £45,641,746. The total receipts, excluding mails and parcels post, amounted to £63,041,034, a decrease of 0·6 per cent., as compared with 1937. The freight hauled totalled 204,493,673 tons, a decrease of 10·4 per cent., the receipts being £67,167,080, a decrease of 6·0 per cent. Train mileage was coaching 248,350,847, and freight 102,648,001, the average train load being 124·75 tons.

ELECTRIFIED RAILWAYS IN U.S.S.R.—On January 1st, 1939, the aggregate length of the electrified railways in the U.S.S.R. was 1690 kiloms., of which 58 kiloms. were put into operation in 1938. It is proposed to electrify an additional 172 kiloms. this year. Electrification will be carried out on the sections Tsaritsino and Podolsk of the Dzerzhinsky Railway, 24 kiloms.; Olenya and Murmansk, of the Kirov Railway, 113 kiloms.; Khashuri and Borzhom, of the Transcaucasian Railway, 32 kiloms. The volume of goods traffic in 1938 on the electrified lines had grown by 20 per cent., as compared with 1937. Long-distance passenger trains on the electrified sections of the Yaroslavl Railway, Moscow and Alexandrov, will now be served by electric locomotives. This year will complete the tenth since the first line in Soviet Russia was electrified—the Moscow and Mytishchi section of the Yaroslavl Railway.

SOUTHEND ROAD IMPROVEMENTS.—The modernisation of the London and Southend road began at the end of 1936, is expected to be completed in August of next year, when there will be dual carriageways and cycle tracks all the way from Harold Wood Station to Southend, a distance of about 18¼ miles. Work is now proceeding on the final section, over 10 miles long, between Dunton Wayletts and the Southend borough boundary, and the Minister of Transport has just made a grant from the Road Fund towards the cost of this section, which is estimated at over £200,000. At present there is only a single carriageway, which motor vehicles share with the large numbers of pedal cyclists. The Essex County Council is providing a new 22ft. carriageway parallel with the old one and two cycle tracks each 9ft. wide. A new footpath, 6ft. wide, will also be provided. Considerable progress has also been made with the modernisation of the road within the Southend borough boundaries.

GLASGOW ACCIDENT REPORT.—The report has been issued on an accident which occurred on September 10th last at Elderslie Station on the Glasgow suburban system of the London, Midland and Scottish Railway Company. It occurred when the 2.30 p.m. passenger train from St. Enoch to Largs collided with a light engine standing in the station. The train was running at about 25 miles an hour, and the collision caused injuries to a large number of passengers, of whom one died. It was found that the accident was caused by a signalman overlooking the presence of the light engine, combined with neglect on the part of the driver of the engine to remind the signalman of his presence. In his remarks concluding the inquiry, Colonel Trench called attention to the number of minor injuries which resulted from the breaking of the thin glass of the photograph frames in the compartments, and suggested that the railway companies should investigate the possibilities of some other form of transparent material for this purpose.

RIBBLE BRIDGE WIDENING SCHEME.—The Minister of Transport has made arrangements for work to begin immediately on the widening of Ribble Bridge, which carries the London–Carlisle trunk road over the River Ribble. The bridge has a width between parapets of little more than 30ft., and, together with its approaches, it is to be widened to 80ft. in order to accommodate dual carriageways (separated by a central reservation) and two footpaths. The work, which is expected to take about twenty-one months, will be carried out on behalf of the Ministry by the Lancashire County Council and is estimated to cost £54,000. The future width of the bridge is the same as that proposed for the adjoining lengths of the trunk road. It has not been thought desirable to provide a width in excess of 80ft. because of the conditions prevailing on the Preston side of the bridge. The widening of the bridge will be carried out on the downstream side, and, with a view to preserving the present appearance, it is intended when building the new parapet wall to use as many of the original face stones as practicable. The original inscription stone will be reset with a record of the widening, and other external features of the old *facade* will be reproduced in the new stone.

Miscellanea

CIVIL AND MILITARY ENGINEERS.—An informal discussion will take place at the Institution of Civil Engineers, Great George Street, on January 18th, at 6 p.m., on Co-operation Between the Civilian Engineer and the Military Engineer. Senior officers of the Corps of Royal Engineers are expected to take part in the debate, and in order that there may be no restraint on the expression of opinion, the Press will not be represented.

AN INDIAN ELECTRIFICATION SCHEME.—As a result of the decision of a committee of experts the Government has decided to undertake the scheme of electrification of the Bihar Province prepared by its special officer. It is proposed to build a central generating station near Dhanbad, where water is obtainable from the Damodar River. The ultimate output of the station will be 50,000 kW, for which plant of 30,000 kW capacity will be installed at first.

SHALE OIL AS A WOOD PRESERVATIVE.—For a number of years Estonian shale oil has been used by that country's national railways as a preservative for wooden sleepers. It is expected, says the *Chemical Trade Journal and Chemical Engineer*, that its use as a wood preservative will increase considerably in foreign markets, following a series of experiments, made by the State Railways Department and the Technical Institute, which have produced very favourable results.

THE HISTORY OF THE THERMIONIC VALVE AT UNIVERSITY COLLEGE.—A lecture on "The History of the Thermionic Valve at University College" will be given by Sir Ambrose Fleming, Professor Emeritus of Electrical Engineering at University College, London, on Tuesday, January 17th, at 5.30 p.m., on the occasion of the presentation to the Department of Electrical Engineering by Mr. McV. Weston of a cabinet with a collection of historic thermionic valves. The lecture is open to the public without fee or ticket.

PUMPING CONCRETE FOR HIGH BUILDING CONSTRUCTION.—In the construction of some new municipal offices in Los Angeles concrete was pumped to a height of 220ft. The frame of the building is of structural steel, the floors, walls and partitions being of concrete. Two 1 cubic yard capacity concrete mixers, designed for continuous operation at a rate of 60 cubic yards per hour, were installed at ground level, and designed to deliver the mixture through a pump and 7in. diameter pipe direct into forms. This method was used up to a height of 140ft., where a booster pump was installed to continue delivery up to a total height of 220ft. above ground level.

THE NICKEL INDUSTRY.—In his review of the nickel industry during 1938, Mr. R. C. Stanley, the Chairman of the International Nickel Company of Canada, Ltd., estimates that world consumption of nickel in all forms during the first ten months of the year amounted to about 168 million pounds. This consumption is a decrease of about 16 per cent. on the same period of 1937, and is attributed to the abrupt drop in business in the United States during the last half of 1937 and first half of 1938. According to estimates, 60 per cent. of the nickel used was in steel, 14 per cent. in nickel-copper alloys and nickel silver, 9 per cent. in Monel, malleable nickel, nickel-clad metal and Iconel, and 6 per cent. was used in electro-deposition work, the remainder being absorbed in various alloys.

GENERATION OF ELECTRICITY.—The official returns rendered to the Electricity Commissioners show that 2675 million units of electricity were generated by authorised undertakers in Great Britain during the month of December, 1938, as compared with the revised figure of 2497 million units in the corresponding month of 1937, representing an increase of 178 million units, or 7·1 per cent. The number of working days in the month, i.e., excluding Sundays and Bank Holidays, was twenty-five, the same as last year. During the year ending December 31st, 1938, the total amount of electricity generated by authorised undertakers was 24,376 million units, as compared with the revised figure of 22,902 million units for the year 1937, representing an increase of 1474 million units, or 6·4 per cent.

DETACHABLE DRILL BITS.—An inquiry addressed to the construction companies engaged in rock excavation in the United States has shown that two-thirds of them use detachable drill bits exclusively, 11 per cent. forged drill steel, and the remainder both types. The inquiry was instigated by *Engineering News-Record*, which says that of those using the detachable bits, 44 per cent. give convenience as the reason, while 40 per cent. regard economy as the outstanding feature. Time saving, elimination of the sharpening shop, and the convenient size range are also listed as points favouring the detachable unit. Many contractors stated objections to the bits, some regarding them as serious enough to prevent their use. Amongst these objections were breaking and excessive wear of threads and rods; failure of manufacturers to standardise on design so as to make different brands interchangeable, and inability to change the temper of the bits on the job to suit various rock conditions.

THE INTERNATIONAL FOUNDRY CONGRESS, 1939.—Arranged by the Institute of British Foundrymen, under the auspices of the International Committee of Foundry Technical Associations, the next International Foundry Congress will be held in London from June 12th to 17th, and will be followed by a tour of the principal foundry centres of Great Britain from June 18th to 24th, and from June 25th to 30th. The President of the Congress will be Mr. W. B. Lake, President of the Institute of British Foundrymen for 1939–40, and the Secretary will be Mr. T. Makemson, Secretary of the Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, 3. It is expected that about 500 delegates will attend the Congress from the majority of European countries, the United States, and from many parts of the British Empire. During the Congress there will be presented more than twenty papers by authors representing the Institute of British Foundrymen, and the equivalent foundry technical associations in other countries. The annual Edward Williams Lecture will be presented by Professor W. L. Bragg.

Air and Water

NEW GERMAN BATTLESHIP.—On Saturday, January 7th, the new 26,000-ton German battleship "Scharnhorst" was officially placed in service. This ship, which was launched on October 3rd, 1936, is 741ft. long at the water line, over 94ft. broad, carries four aeroplanes, and mounts 11in. guns.

LAID-UP SHIPPING IN SOUTH WALES PORTS.—On January 1st there were forty-two ships laid up in the ports of South Wales, as compared with eighteen last year. Twenty-four of these ships were British and the remainder foreign, thirteen of them being Spanish ships which have been lying idle for over two years.

A COMMERCIAL AEROPLANE RECORD.—A new record time for the journey from Croydon to Brussels was set up on January 9th by the Imperial Airways liner "Falcon." The machine covered the distance in forty-eight minutes at an average speed of 250 miles an hour. It was carrying a crew of four, eleven passengers, and a ton of freight.

NEW BRITISH DESTROYER.—On Monday, January 9th, a new destroyer of the "K" class, H.M.S. "Kingston," was launched from the yard of J. Samuel White and Co., Ltd., at East Cowes. Six other destroyers of the same class and a flotilla leader are under construction. The new ship is 348ft. long, 35ft. 8in. in breadth, has a standard displacement of 1690 tons, and will be propelled by twin-screw single-reduction turbines of about 40,000 S.H.P. She will carry 4·7in. guns, anti-aircraft guns, and torpedo tubes.

MR. A. H. PARKER'S RETIREMENT.—Mr. A. H. Parker, superintendent engineer of the New Zealand Shipping Company, Ltd., since 1925, retired at the end of December, 1938. He was born in 1869 and joined the company in 1896. He reached chief engineer rank in 1904. In 1920 Mr. Parker was appointed assistant superintendent engineer, and held this post until he was made superintendent engineer in 1925. His successor to the post is Mr. G. Ormiston, who was the assistant superintendent engineer.

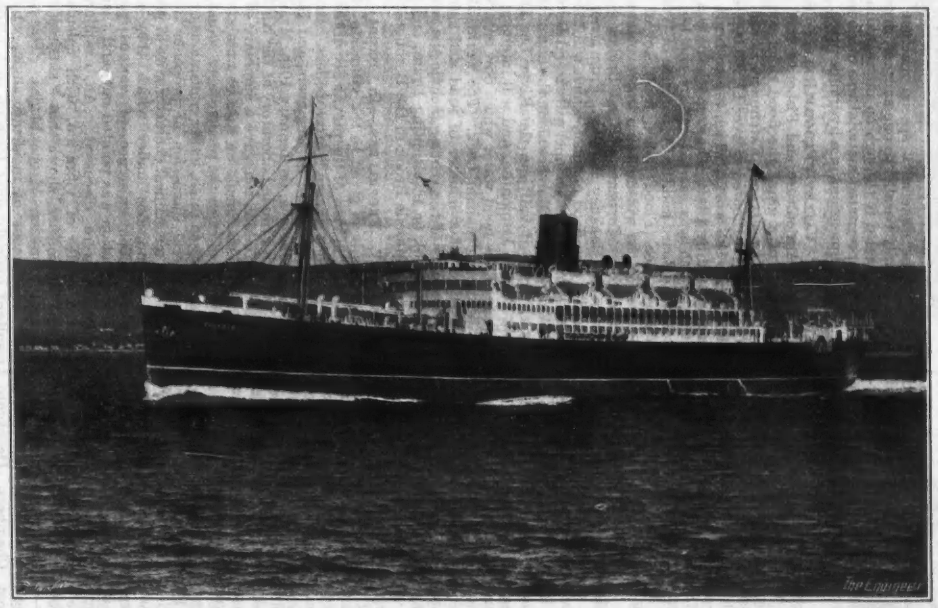
THE PRICE OF SHIPS.—At the launch of the new Elder-Dempster motorship "Sansu," Colonel Alan C. Tod said that the second largest item in this country's invisible exports was shipping earnings. He pointed out that the cost of a ship similar to the "Sansu" had risen by 50 per cent. since 1936, and to earn profits the shipowners must buy ships at the world's price and not at a protected figure. He suspected that the naval construction in this country had converted shipbuilding into a sheltered industry, building in an uncompetitive market.

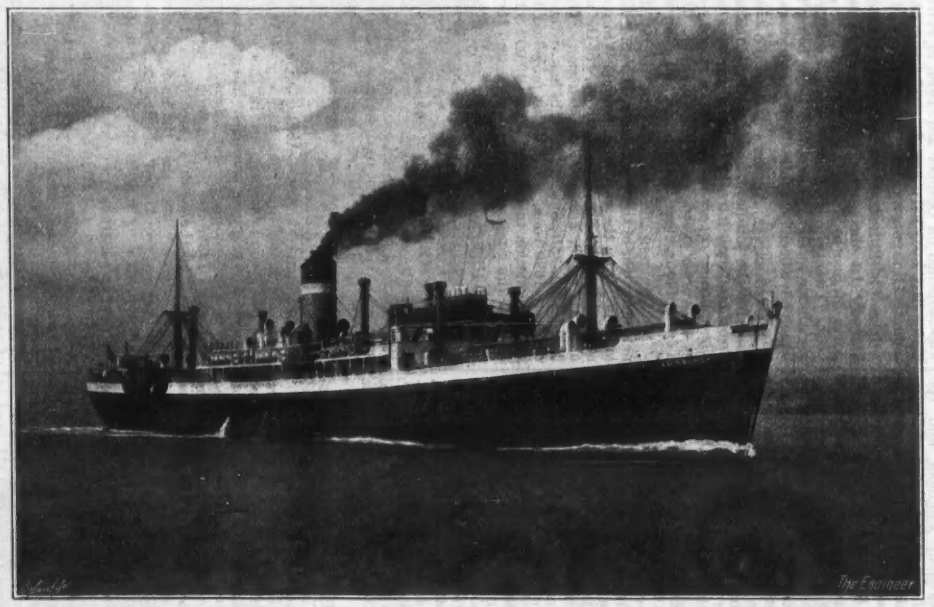
PLASTICS IN AIRCRAFT CONSTRUCTION.—In the course of a paper before the Weybridge branch of the Royal Aeronautical Society, Dr. N. A. de Bruyne said that a new synthetic material had been produced with properties which made it suitable for aircraft construction. It now remained to ascertain methods of producing and utilising the material. In making the material linen had been substituted for cotton and gave twice the strength and three times the stiffness. For producing the material a special machine arranged the fibres uniformly parallel to one another, drew them into a band, and passed it through an impregnating bath. The dried and impregnated material was made into a plank of any desired dimensions in a hydraulic press.

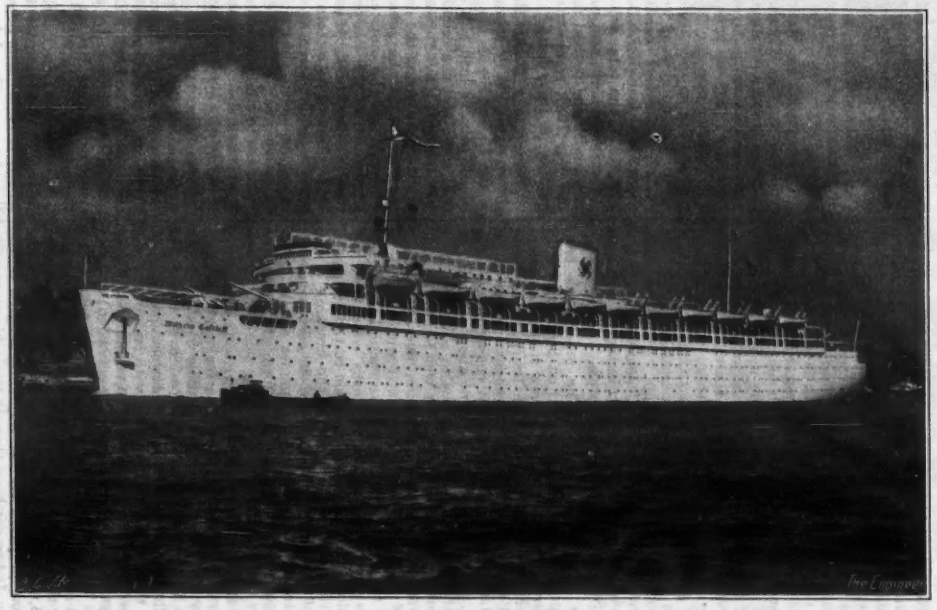
THE LEE VALLEY FLOOD RELIEF SCHEME.—The Ministry of Agriculture and Fisheries has approved for the purpose of a grant the flood relief scheme prepared by the Lee Conservancy Catchment Board. The cost of the scheme is estimated at over £1,200,000, and it is anticipated that the works, which are to begin at once, will be completed by 1944. The new scheme is a continuation of that which was carried out by the Lee Conservancy Catchment Board and the Corporation of West Ham under the River Lee (Flood Relief, &c.), Act of 1930, and it provides for the widening and improvement of the River Lee from near Carpenters' Road Bridge, Stratford, to a point on the Hackney Marshes. From there it is proposed to build a new flood channel, which will have a length of about 3½ miles. The channel will extend across the Leyton and Walthamstow Marshes along the line of the Dagenham Brook, where it will join the River Lee Diversion near Chalk Bridge, Edmonton, and will intercept about three-quarters of the flood water which now enters the Navigation below Tottenham Lock. The work will include the construction of a number of road and railway bridges. Other sections of the scheme include the widening of the Pymmes Brook or Intercepting Drain, and the improvement of the Moselle Brook in the Borough of Tottenham.

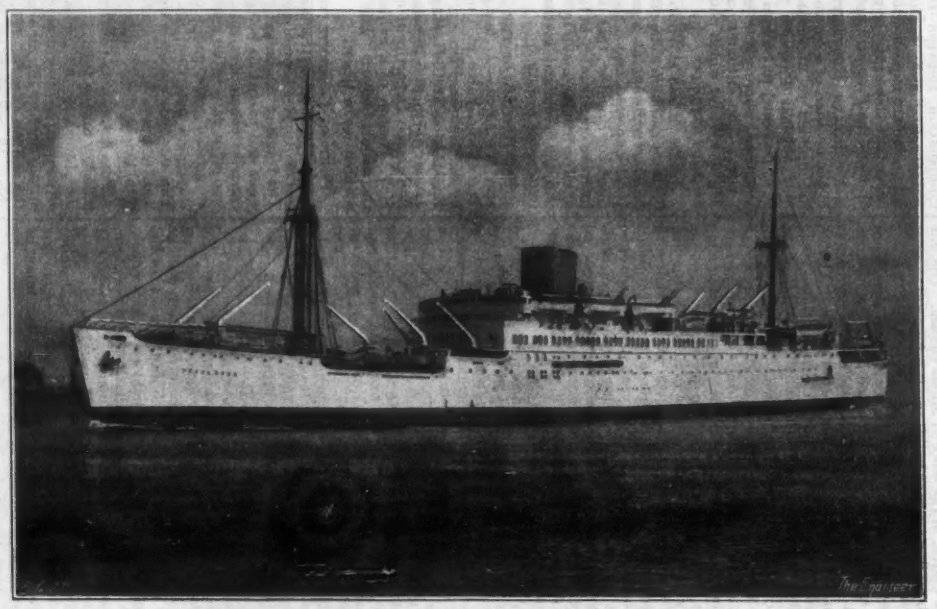
"SINGING" PROPELLERS.—In recent years much attention has been given to the vibration of marine propeller blades, in view of the prevalence of the phenomenon known as the "singing" of propellers. In a paper read before the Institution of Engineers and Shipbuilders in Scotland at Glasgow, on January 10th, Mr. J. F. C. Conn, of the William Froude Laboratory at the National Physical Laboratory, Teddington, gave a summary of observations of propeller noise made on a large number of ships. In the majority of cases the predominant sound was found to be a note of fixed pitch, either continuous or intermittent. After a general discussion of propeller noise, the geometrical and mechanical characteristics of propeller blades and the conditions under which they operate were described. The existence of various periodic forces exciting vibration was pointed out, and their nature and magnitude were discussed. An examination of the possible modes of vibration, with calculations of the natural frequencies, shows that "singing" is caused by torsional vibration of the blades. The variable wake leads to changes of incidence angle, which cause the resultant hydrodynamic force on each blade to change in magnitude, direction and location; in particular, the centre of pressure may oscillate in position about the flexural centre, thus causing changes in sign of the twisting moment, and thereby exciting torsional vibration. Possible methods of obviating "singing" were examined in detail. Since the phenomena involved concern both hull and propeller, and the existence of a variable wake cannot be avoided, the adoption of blade sections having fixed centre of pressure was advocated.

(For description see page 62)









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GERMAN MOTOR LINER "WILHELM GUSTLOFF"

ELLERMAN LINER "CITY OF EDINBURGH"
K.P.M. MOTOR LINER "TEGELBERG"

The Engineer

JANUARY 13, 1939

VOL. CLXVII No. 4331

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NOTICES TO READERS

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CHANGES OF ADDRESS

**** Will Subscribers please note that in all advices regarding changes of address it is necessary to have* **both the old and new addresses,** *as our lists are kept alphabetically by towns. Advices of this nature should reach us by the first post Wednesday morning prior to the alteration.*

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EDITORIAL ANNOUNCEMENT

With our next issue we shall publish as a Supplement a "Tabular Summary of Civil Engineering Contracts of 1938." This Summary will contain particulars of large works completed or in progress, under British direction, both in this country and abroad. The issue will also contain the Index to Vol. CLXVI (July–December, 1938).

THE EFFICIENCY OF STEAM TURBINES

THE best way of determining the merit of a steam engine of any kind is to compare its performance with that of a perfect engine working under the same steam conditions. There is no difficulty in imagining such an engine, devoid of friction, heat conduction, leakage, and other defects. Carnot, indeed, had the idea more than a hundred years ago and laid the foundations of thermodynamics by showing the maximum efficiency that a perfect engine could have. This efficiency, moreover, was quite independent of the working substance, provided that the latter passed through the cycle of changes involved in the action of the engine. The cycle was simple enough; indeed, from the scientific point of view, it could hardly have been simpler, but unfortunately it required one operation, namely, the adiabatic compression of the exhausted substance from its final to its initial temperature, which could not be carried out practically in the case of steam. Other cycles of operation, devised later by Stirling and Ericsson respectively, had the same efficiency as the cycle of Carnot, but, like his, they were inapplicable to an engine working with steam. A cycle much more akin to that upon which all the early steam engines worked is the one associated with the name of Rankine. It differed from that of Carnot in assuming that the water is heated, and the steam superheated, by heat taken in at varying temperatures and not all at the highest temperature of the cycle as required by Carnot. A perfect engine working on the Rankine cycle will be definitely less efficient than one working on the Carnot cycle between the same temperature limits; but this drawback, if it is one, is more or less compensated for by the closer resemblance which the former cycle bears to the processes taking place in practice. The analogy is, indeed, good enough for the calculated performance of a perfect Rankine engine to have been universally accepted as the standard of efficiency. The merit of any actual engine could then be expressed by its "efficiency ratio," a term introduced by the late Captain Sankey to denote the percentage of the Rankine efficiency that was attained by the engine.

The Rankine cycle, considered as a criterion of performance, fulfilled all requirements for many years. No matter how pressures, temperatures, and vacua might vary between one plant and another, it still represented the cycle of operations aimed at, and its offspring, the efficiency ratio, was a fair measure of the excellence of the prime mover. But the improvements in steam practice that followed the development of the steam turbine destroyed the former simplicity of things. The heating of the feed water progressively by means of partially expanded steam is quite inconsistent with the Rankine cycle, which therefore no longer provides any useful standard of comparison. For this reason one hears very little nowadays about efficiency ratios, and turbine engineers have had to fall back upon the fundamental statement of the heat consumption per kWh of useful work. It would, nevertheless, be very convenient if some standard cycle could be adopted which would reflect the ultimate aims of designers, particularly as regards progressive feed heating. One difficulty in doing this lies in deciding how far we may legitimately be influenced by what is practicable to-day and what is not. In 1922 the Heat Engine Trials Committee, representative of all the leading engineering institutions and the technical departments of the Government, considered, amongst other things, the question of replacing the Rankine cycle. Their Report, issued in 1927, recommends that the efficiency of the perfect engine should be calculated on the assumption that the feed water is raised to its final temperature in a single stage, although in the recommended form of tabulation of turbine tests as many as three stages of feed heating were provided for, and more than this are used to-day. Single-stage feed heating cannot, of course, be a thermodynamically reversible process, and for that reason it is incompatible with the conception of a perfect engine, apart altogether from the fact that it does not accord with the actual cycle. Another assumption made by the compiler of the 1927 Report was that steam would not be tapped off for feed heating until after it had lost its superheat by adiabatic expansion in the turbine. This was a convenient way of dodging the theoretical difficulty with regard to feed heating by means of superheated steam, but it is a difficulty which should have been faced, particularly as such steam is commonly used now in H.P. feed water heaters. The ideal method of progressive feed water heating would be a continuous process in which the condensate flowed counter to the expanding steam, and at every point, extracted from it the amount of heat required to raise it to the same temperature. This is what the designer would like to arrange for, and he approximates to it as nearly as he can by multiplying the number of his feed heaters. It seems to be beyond argument that a cycle embodying continuously progressive feed heating should form the basis of comparison for all turbines from which steam is extracted for feed heating purposes. In the discussion of Mr. C. D. Gibb's paper on "Steam Turbine Practice," read before the Institution of Mechanical Engineers in 1931, Dr. Gerald Stoney illustrated the method of computing the efficiency of such a cycle, attributing the suggestion to Captain Sankey, who died in 1925. The idea, therefore, is by no means new. It is still, however, waiting for official recognition, for though a continuously progressive feed heating cycle was discussed and advocated in the provisional Report of the Heat Engine Trials Committee, printed in 1926, the final Report, which appeared the following year, put forward the quite different view upon which we have commented above.

The practice of resuperheating the steam during its expansion is another matter which must be taken into account in any attempt to specify a standard cycle to do for modern turbines what the Rankine cycle did for engines of a former day. At present one resuperheating is as much as has been attempted in commercial machines, and it is not a difficult thing to modify the Rankine cycle to provide for this. But there is no reason why future designers should limit themselves to a single reheat. As long ago as 1904 Ferranti built an eight-stage impulse turbine arranged for resuperheating the steam to its initial temperature after every stage but the last. The machine was not a success, but that was no fault of the principle. If practical difficulties could be overcome, there is much to be said for multi-stage reheating. Carried to its theoretical limit, it would result in an isothermal expansion of the steam until the last stage of the turbine was reached, and as all the heat of the process would be absorbed by the working substance at the highest temperature of the cycle, the maximum efficiency would be obtainable. The achievement of what would virtually amount to continuous resuperheating may be too far in the future to be worth much consideration at present, but its theoretical possibility is not to be ignored. It raises the question whether the designer who adopts resuperheating at all should not be credited with the attempt to approximate to isothermal expansion, just as the use of multiple feed heaters may be properly considered as an attempt to approach the goal of continuously progressive feed heating, right up to the boiler temperature. A standard cycle based on these two assumptions would be an extremely severe criterion of performance of any actual turbine, and the designer might almost be forgiven if he said he would just as soon have the Carnot cycle and be done with it. But it would at least be a logical one, and would not call for any modification in consequence of any foreseeable developments in turbine practice. It should, however, be pointed out that the progressive feed heating of the feed water up to full boiler temperature, which is required for the maximum efficiency, would hardly be attempted in practice because of its bad effect upon the efficiency of the boiler plant. Again, in order that all the processes of the suggested cycle should be thermodynamically reversible—and this seems essential if it is to form a standard of comparison—provision must be made for dealing with the question of superheated steam for feed heating. If the steam, after expansion in the turbine down to the required feed temperature, is still in the superheated condition, as it always must be if feed heating is carried right up to the boiler temperature, its pressure will necessarily be lower than that of saturated steam at the same temperature. To allow it to give up its heat reversibly to the feed water its pressure must be raised to the pressure of saturation by isothermal compression, and the work for doing this must be deducted from the output of the perfect engine. This complicates the calculations a little, but it is unavoidable. The real difficulty, however, with regard to establishing a standard cycle to replace that of Rankine is not that of calculations at all, but consists rather in the question of deciding exactly what the ideal turbine may reasonably be expected to do in the way of feed heating and resuperheating. Until agreement is reached on this matter we shall have to get along as best we can without thinking about efficiency

ratios overmuch, and it may well be that the present practice of comparing turbines on the basis of heat consumption per kWh will be found, on the whole, adequate to our needs.

Technological Restraints

WE gather from our American exchanges that the opposition to technological advances is still active in the United States. It is surprising that it should have come into being at all in a country which, for nearly a century, has been the actual and spiritual home of "notions" and inventions, and has led the world in the ready and rapid adoption of new methods and new things. But so it is. Forced at last to recognise that a system once deemed perfect logically, and inviolable practically, had failed to give that constant employment to all which in principle it should have done, the Americans have had to get their hands upon a scapegoat. And, just as in this country, they have picked out, in defiance of history, the never-ending advances of the inventor. He is the *diabolus ex machina*. He it is who, by devising new methods of hastening production, is throwing millions out of work; he it is who, by continually devising new commodities and amenities, is for ever unsettling the people and upsetting finance.

It appears that even the Monopoly Investigating Committee which is now sitting on the other side is influenced by the popular feeling against the applied scientist and engineer. It sees the industries of America in immediate danger. It has terrible visions of a bright inventor suddenly springing upon his country some new process, or material, or some new manner of doing things, that will cut right across existing methods, and throw industries on the scrap heap. Away would go invested capital; away would go valuable plant; away would go the trained employee. And goodness knows what repercussions there would be! One inventor might destroy the whole steel industry by producing a rustless material, light as aluminium, and with a tensile strength of 50 tons; another, by a flash of genius, might cast the heat engine as we know it on the dump; whilst a third might startle the world by producing a catalytic prime mover which would make its own fuel as fast as it used it! Absurd as all such ideas are in the eyes of engineers, it is scarcely surprising that a world fed with the wonders of applied science has been brought to a condition in which it believes nothing to be impossible. Let us grant that it has some reason for that belief; let us go even further and avow a faith that things seemingly impossible to-day will be the commonplaces of next century. Yet the fact remains that in the whole field of technological developments nothing has ever happened suddenly. In science, yes. Discovery is often instantaneous in itself, though the ground from which it springs may have been under cultivation for many years. We may mention Roentgen rays and the vulcanisation of rubber as examples. But between a scientific discovery and its application on a scale sufficient to affect industry a great gulf is fixed. The world has lots of time to accommodate itself to the new conditions; they come upon it by slow degrees, not overnight. For years there is overlapping; the old existing side by side with the new. Even now, after forty years of the motor vehicle, you may see hansom cabs upon the streets of London, and no motorist but inveighs against the persistence of horse-drawn carts and lorries. The internal combustion engine came as a defiance to the steam engine at sea, but has not driven it out of existence; the steam turbine has failed to replace completely the reciprocator. The telephone has not diminished the number of telegrams, and wireless has not yet ousted the telegraph. Any engineer could multiply examples to his heart's desire. But it is difficult to convince the public that no new invention ever comes so suddenly that it upsets the social order or that it ever has a malign influence upon employment. Invariably, the new invention adds to the number of people engaged, and invariably it takes so long to reach a position of magnitude that the world is able to accommodate itself to the new thing without much discomfort. What we want now is not the cessation of invention, but the introduction of something that would lead to the building up of a new industry. Oh! for another Faraday, another Starley, another Marconi!

Here, no less than in America, one may hear people asking what the Government is going to do about it; what steps are being taken by the State to arrest the progress of technology? As if any legislation were needed. It is a pity that there are not many popular books about the history of applied science; books attractive enough to be best sellers. Then the protesting public would see what long and wearisome years every invention or discovery must pass through before it is stabilised; the difficulties of a material nature that have to be overcome; the endless expenditure of money, often with but little return; the fight against vested interests; the long struggle to find markets. All these things combine to create an inertia opposed to sudden development and rapid change that is more potent than legislation could ever be, and render artificial restrictions as unnecessary as they would, inevitably, be injurious.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

DIMENSIONLESS CHARACTERISTICS OF FANS AND CENTRIFUGAL PUMPS

SIR,—During the past summer the writer investigated the efficiency a small high-speed centrifugal air blower when working at the optimum efficiency point, by means of the usual methods of dimensional analysis, and also, to a very limited extent, by experiment. Some of the results of the dimensional study may be of interest to designers of fans and centrifugal pumps.

The variables entering the problem are—the gravity constant g (32·2ft. per second^2), the total head h (feet) imparted to the fluid, the kinematic viscosity ν (feet^2 per second) of the fluid, the speed n (revolutions per second) of rotation of the impeller, the diameter d (feet) of the impeller, the quantity q (feet^3 per second), and the weight w (lb. per second) of fluid discharged, and the horse-power P absorbed at the shaft.

These variables can be arranged in a variety of "dimensionless" groups, but the following three are of outstanding importance in the investigation of optimum efficiency—the "efficiency" group, $wh/550P$; the "specific speed" group, $n\,q^{\frac{1}{2}}/g^{\frac{1}{2}}h^{\frac{3}{4}}$; and the "combined Reynolds' Number" group, $q\,n\,d/\nu^2$. The last group is obtained by multiplying the impeller disc Reynolds' Number $n\,d^2/\nu$ by the fan or pump passage Reynolds' Number $q/\nu\,d$. The dimensionless nature of the groups enables results from fans and pumps of the same geometrical design, but of different sizes and dealing with fluids of different kinematic viscosities, to be correlated. They can be plotted one against another, as shown in an exaggerated way in the accompanying figure.

Fans and pumps may be roughly divided into "classes"—turbine, volute, mixed flow, and propeller—in rising order of specific speed. Each class may be divided into a multitude of different "designs," and each design may be further subdivided into a "range" of sizes, each of which is more or less geometrically similar to the other members of the range. Each size, too, may be used to deal with fluids possessing quite a "range" of kinematic viscosities. Size (which also fixes the speed and quantity discharged at the optimum efficiency point) and the kinematic viscosity, together determine the Reynolds' Number "range" for the range of sizes. The relationships between class, design, and Reynolds' range are tentatively sketched in the figure.

The writer's experiments were confined to one optimum specific speed, the highest Reynolds' Number $q\,n\,d/\nu^2$ being only four times the lowest. The results as analysed so far show that the efficiency is practically independent of Reynolds' Number.

The experimental results obtained by Dr. H. Mawson,* from a small centrifugal pump working with water and with various oils and sulphuric acid of kinematic viscosities up to about 107 times that of water, tend to show an increase in the efficiency with increasing Reynolds' Number. The highest combined Reynolds' Number in this set of experiments was about 11,400 times the lowest.

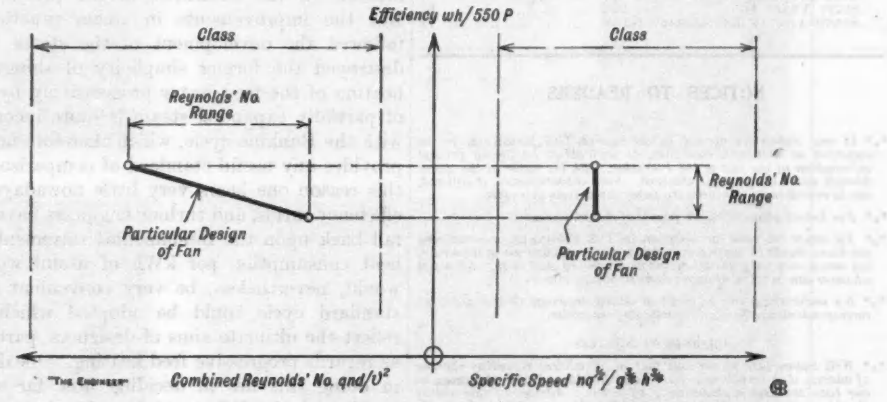
Experiments by R. S. Capon and G. V. Brooke† on a single-stage star wheel supercharger indicate a very slight increase of efficiency at the higher Reynolds' Numbers. As the speed of the blade tips approaches the velocity of sound, however, the efficiency tends to fall.

Should any of your readers who are interested in fan and pump efficiency possess comparative test figures, it would be very instructive to learn whether they show a variation of efficiency with Reynolds' Number as well as with specific speed.

It is to be noted in conclusion that the specific speed $n\,q^{\frac{1}{2}}/g^{\frac{1}{2}}h^{\frac{3}{4}}$ given above is "dimensionless." The form $N\,Q^{\frac{1}{2}}/H^{\frac{3}{4}}$, where N=revolutions per minute, Q=gallons per minute, and H=head in feet, usually applied in centrifugal pump analysis, is not dimensionless.

G. G. MCDONALD.

The Engineering Department,
The University, Glasgow, W.2,
December 26th, 1938.



PRODUCTION AND EFFICIENCY

SIR,—Dr. Bowley's Presidential Address to the Royal Statistical Society, of which an abstract and editorial comment appear in your issue of December 9th, raises some questions of the highest interest to engineers in particular and to the British public in general.

The main impression which is suggested by the address is that (1) a general distribution of the present total product would only very slightly raise the standard of living of the average man; (2) the cost of energy is a relatively unimportant part of production costs; and (3) the benefit to the average man of increased efficiency in production is largely offset by the reduction of working hours and the increase of prices, the latter partly due to distribution costs. According to his figures, "*real* weekly wages" have only increased by less than 40 per cent. since 1860.

The first contention definitely negatives generally credited estimates as to the early possibility of

* Proc. Inst. Mech. E. 1927, p. 1037-1045.

† R. and M. Aer. Res. Comm. Nos. 1336 and 1503.

improvement ranging from 100 per cent. upwards. Dr. Bowley takes a figure of £4000 millions as the approximate annual value of "goods and services," and deduces that this corresponds to an hourly wage of about 1s. 6d. Is it, however, not a fact that the £4000 millions does not include certain imponderable "services," such as entertainment, research, police, medical attention, fire brigades, &c., which may represent, say, another £1000 millions, raising the mean figure to, say, nearly 2s. per hour, or perhaps 25 per cent. more. Furthermore, an appreciable fraction of production is of a luxury or futile character, which would have a much higher utility value if adapted for general use. Thus, one high-class motor car costing, say, £2000 and lasting, say, ten years, might be substituted by ten ordinary cars, lasting, say, five years, so that five times the utility would be gained.

Copious advertisements, patent medicines, shoddy or fragile clothing, and other similar trashy products, and exports not paid for by imports, are similar causes of waste of effort.

As to energy costs, Dr. Bowley has perhaps not sufficiently considered that energy enters repetitively into production at all stages, and also plays an overwhelmingly important part in reducing labour costs per unit of output. He remarks that only some 10 per cent. of occupied persons are engaged in coal, electric, and gas undertakings, and that railway companies only spend 10 per cent. of their costs on fuel, &c., but all the annual charges in respect to the plant and machinery of these bodies also include energy cost items, and there are many other persons beside those actually in coal, electric, and gas undertakings who participate in energy supply. The more the unit cost of energy is reduced, the greater the quantity of it which will be used in place of labour, thereby reducing wages per unit of product. The difference between the cost of natural energy and the wages of human energy is the mainspring of all mechanical production.

Lastly, as to the question of working hours. There is probably an optimum period which gives the maximum production having regard to all the conditions, not excluding the physical and mental well-being of the producers.

These considerations rather change the aspect of the problem as Dr. Bowley has presented it.

HERBERT CHATLEY.

London, S.W.1, January 9th.

THE GENISSIAT DAM

SIR,—Is it possible to publish further information on the Genissiat Dam, described in the interesting article in your issue of December 30th?

Why did the engineers decide to drive two diversion tunnels when one alone has sufficient capacity to discharge 2000 cubic metres per second, the maximum recorded flood discharge? Surely it would have been a far less costly matter suitably to increase the thickness of the concrete invert to withstand any erosion that may take place before the dam is completed and the tunnel put out of commission.

If the solid content of the water is so high as dangerously to erode the tunnel invert, will it not produce very serious erosion in the turbines and their attendant penstocks, &c., in its passage through them? It is true that the penstock intakes are situated some little distance upstream of the dam, thus giving the effect of a forebay or settling pond, but if the velocity of the water is reduced sufficiently to precipitate the solids, the capacity of the reservoir will be seriously reduced in a comparatively short time.

Furthermore, having driven the two diversion tunnels, why is not one of them retained and used for the purpose of flood discharge, thereby eliminating the necessity for another costly tunnel?

Information on these matters would enhance the value of your description of the preliminary works at the dam.

E. B. PARKER.

Hutton, Essex, January 2nd.

[The discharge capacity of a single diversion tunnel reaches the maximum of 2000 cubic metres per second only when the head of water is equivalent to a level above the dam of + 325·0 m. The discharge capacity of one tunnel when the water level upstream is just below the top of the temporary cofferdams is very considerably less than this figure. Both diversion tunnels are needed to discharge a flood of 1470 cubic metres per second without risk of overtopping the upper cofferdam. The water which will pass through the turbines when the reservoir is functioning will be drawn in at a relatively high level, as is shown in the cross section, Fig. 4 on page 724. The greater part of the solid content of the water will settle above the dam. The objection to the retention of the two diversion tunnels as a normal provision for flood discharge after the completion of the works is that both tunnels are situated at a low level. The operation of large control sluice gates in them would be impracticable under the head of water to which they would be subjected when the reservoir is full. This point is brought out in the section headed "Sluice Gates and Cofferdams in Diversion Tunnels," on pages 723 and 724. One of the tunnels is, in fact, intended as an emergency spillway, which can be brought into operation by blowing out the steel diaphragm described in the article. This operation is, however, never likely to be necessary. It should be noted that the control sluices of the power house intakes and of the permanent flood discharge tunnels are all situated at relatively high levels at which the operation of large gates will be practicable. As regards our correspondent's question about erosion of the tunnel invert, we know of no special reason to anticipate rapid erosion of the concrete surface. The designers may have contemplated the possibility of repairs and at the same time may regard the necessity for them as a remote one.—ED., THE E.]

GEODETIC CONSTRUCTION.

SIR,—Engineers have been waiting for a description of the Vickers-Wallis geodetic system of constructing aeroplane fuselages and will be pleased to see that the company has at last released some particulars, as given in your number last week. For myself, I must express some surprise that they should ever have been hush-hush, at least as far as their geodetic qualities are involved.

Whilst I do not query for a moment that the construction may be a very good one, and that the stresses may be taken up as indicated in your description, yet I fail to see any magic in the fact that the members follow a continuous geodetic line. Perhaps there never was meant to be any magic in the conformation, and it was the rather exceptional use of the word geodetic that led us to think that a new discovery had been made.

A geodetic line is the shortest path between two given points on a solid surface in a prescribed sense. If any two points be selected on a cylinder the shortest piece of string that will join them is a geodetic. If a number of points be marked on a longitudinal line on the cylinder and the cord be wound to pass through them all in a smooth continuous curve, it will be a geodetic. A normal screw thread is obviously a geodetic of constant pitch. If it is desired to vary the pitch and preserve smooth transition, it is quite easy to do, as every screw cutter knows. It is also easy to cut a continuous spiral on a cone; it may be of contant pitch or vary as the diameter changes. The point I am trying to make is that any smooth continuous spiral on a curved surface must be a geodetic and cannot be anything else. Any number of such lines may be described with a bit of string wound round appropriate objects; but, of course, friction *must* be absent. Try it on a bottle, a tapering flower vase, and so on.

An interesting fact arises from such demonstrations. Since the total length of the string is the shortest possible in the circumstances, all tensile stresses must pass through it, and hence the curve cannot be deformed by tension. That, I think, is one of the principal claims for the geodetic system of construction, but since in a hollow structure the supporting body which I have predicated is absent it would appear that tensile forces would in fact distort the form. It will be observed, in fact, that such distortion is ingeniously provided against by using two geodetic spirals of opposite hand.

My excuse for this long letter, which is not meant to be in any way a criticism of the geodetic fuselage, is that these geometrical curves are always entertaining.

M. L. M.

January 5th.

SIXTY YEARS AGO

Gun Explosion on H.M.S. "Thunderer."—To the superstitious the period from September, 1878, to December, 1879, must have seemed to provide evidence in support of the old belief that mishaps occur in cycles of three. Between those dates the people of this country had to bear the shock of three memorable disasters—the sinking of the excursion steamer "Princess Alice" in the Thames; the explosion of a 38-ton gun on the "Thunderer," one of our latest battleships, and the fall of the Tay Bridge. The mishap on the "Thunderer" was first mentioned in our issue of January 10th, 1879, but we have to read many subsequent articles on it before the whole story becomes clear. The battleship, a sister of the "Devastation," carried two twin-gun turrets. The forward turret contained two 38-ton and the after turret two 35-ton guns, but, in order that both turrets might fire the same size of shell, the bore of the 38-ton guns had been reduced from the normal 12½in. to 12in. They were muzzle-loading, wrought-iron guns of partially coiled construction. The loading and operation were performed hydraulically and hydraulic rams were provided to take up the recoil. To load them the guns were tilted down until their muzzles came below the level of the deck. The loading crew, stationed below deck outside the turret, thereupon rammed home the charge and then the shell. Not only were the guns, by virtue of their reduced diameter, stronger than the normal 38-ton gun, but, for the same reason, they were loaded with a reduced charge and a lighter shell. It is therefore easy to understand the dismay which was caused when the news was received that one of the 38-ton guns had exploded with great violence during a practice shoot at Ismid on January 2nd, 1879. All but one of the turret crew were killed. For a time various theories to account for the accident were hotly debated. According to one view the shell had jammed in the bore of the gun. According to another the downward tilt of the gun while it was being loaded had resulted in the shell slipping forward after it was rammed home, with the result that at the instant of firing an air pocket existed between the charge and the shell. An expert committee was appointed to conduct an inquiry. When it published its findings the mystery was resolved in a startling manner. The gun had accidentally been double-loaded. On the day of the disaster an attempt had been made to fire all four guns simultaneously by electricity. It was known that only one of the guns in the after turret had gone off, but it was believed that both the forward guns had been discharged. An order was then given to reload the three discharged guns and to fire them off one at a time, beginning with the forward turret. The first gun of that turret was discharged successfully. The second exploded violently. The weight of the evidence subsequently collected served to show that this gun had misfired during the previous broadside, and that when an attempt was made to fire it later its original charge of 110 lb. of powder and a Palliser shell had superimposed upon it another charge of 85 lb. of powder and a common shell. Why did the loading crew not notice that the rammer had not gone into the bore to its normal extent on the second loading? The cord of the tell-tale had broken. Why did they not notice that the rammer had stopped moving earlier than it should have done? The rammer was made of highly polished steel and it was very difficult at any time to see whether it was moving or stationary. Why did the turret crew fail to detect the absence of recoil which, during the broadside practice, would have indicated a misfire? The hydraulic gear withdrew the gun for reloading so quickly and promptly after firing that the motion could mask the recoil. Many incidental facts supported the committee's conclusion, although for a time a number of well-known authorities were disinclined to accept it. Their scepticism may, after all, have been justified. Three of the ship's company, including the captain himself, swore that they saw *three* shells falling into the water during the broadside practice. The turret crew—obviously, and by the testimony of the sole survivor—were certain that the gun had gone off. One of the loading crew told the committee that when the gun was presented for reloading smoke was coming from its muzzle.

BOOKS RECEIVED

Mechanical Drawing. By E. S. Youngberg. London: Sir Isaac Pitman and Sons, Ltd., Parker Street, W.C.2. Price 3s. 6d. net.

Lanchester's "Potted Logs." By Dr. F. W. Lanchester. London: Taylor and Francis, Ltd., Red Lion Court, E.C.4. Price 1s. net.

Timestudy for Cost Control. By P. Carroll. London: McGraw-Hill Publishing Company, Ltd., Aldwych House, W.C.2. Price 18s. net.

Science in Africa. By E. B. Worthington, M.A. London: Oxford University Press, Amen House, Warwick Square, E.C.4. Price 10s. 6d. net.

The Training of the Upper Nile. By F. Newhouse, B.Sc. London: Sir Isaac Pitman and Sons, Ltd., Parker Street, W.C.2. Price 6s. net.

Meter Engineering. Third edition. By J. L. Ferns, B.Sc. London: Sir Isaac Pitman and Sons, Ltd., Parker Street, W.C.2. Price 12s. 6d. net.

Air Conditioning. Second edition. By J. A. Mayer and R. V. Fittz. London: McGraw-Hill Publishing Company, Ltd., Aldwych House, W.C.2. Price 24s. net.

Performance and Design of Direct-current Machines. Second edition. By A. E. Clayton, D.Sc. London: Sir Isaac Pitman and Sons, Ltd., Parker Street, W.C.2. Price 16s. net.

The Elements of Radio Communication. Second edition. By O. F. Brown, M.A., and E. L. Gardiner. London: Oxford University Press, Amen House, Warwick Square, E.C.4. Price 16s. net.

A Pocket Book for Mechanical Engineers. Revised edition. By D. A. Low, M. I. Mech. E., edited by B. B. Low, M.A. London: Longmans, Green and Co., Ltd., 39, Paternoster Row, E.C.4. Price 10s. 6d. net.

Shipbuilding & Marine Engineering in 1938

No. II

(*Continued from page 26, January 6th*)

WE continue in what follows our description of some of the outstanding ships which were built and engined in British and foreign shipyards and engine works during the past year.

The Shaw Savill and Albion Liner

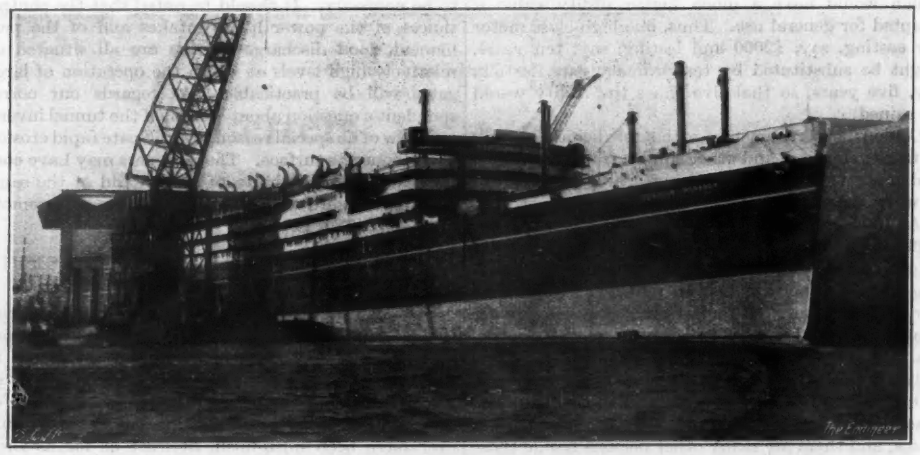
An important link in our Empire service was practically completed during the year and will undergo service trials towards the end of the present month, ready for the maiden voyage to Australia and New Zealand *viâ* South Africa early in February. She is the new Shaw Savill and Albion Company liner "Dominion Monarch," which was launched on Wednesday, July 27th. A view of the ship fitting out at Swan, Hunter and Wigham Richardson's Wallsend yard is given herewith, while in addition we illustrate one of her main engines. They comprise four units of the Doxford opposed-piston pattern, having five cylinders with a bore of 725 mm. and a combined stroke of 2250 mm., the designed output being 7700 S.H.P. at 133 r.p.m., giving a total power of 30,800 S.H.P. Doxfords supplied two engines and the remaining two were constructed by the shipbuilders. The "Dominion Monarch" has an overall length of 682ft., with a breadth moulded of 84ft. 6in., and a depth to the bulkhead deck of 48ft. 6in. She will have a loaded displacement of about 36,000 tons, with a measurement of about 27,000 gross tons. The accommodation, which has been laid out on a generous scale, is planned to take 524 first-class passengers. Welding has been freely used in the construction of the hull and machinery.

The New Glen Line Motorships

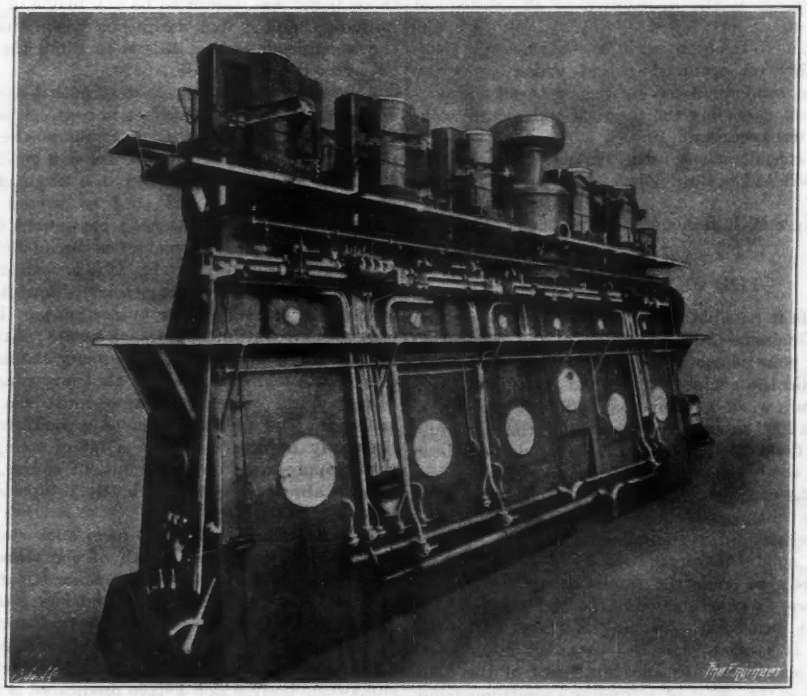
The new cargo liners of the Glen Line, Ltd., are of special interest as they represent the latest development in fast cargo motorship construction. The Glen Line was one of the earliest British companies to own motorship tonnage, and since it has come under the management of Alfred Holt and Co., eight new ships have been ordered for its services to the Far East. By the end of last year two of these ships, the "Glenearn," built by the Caledon Shipbuilding and Engineering Company, Ltd., of Dundee, and the "Glenroy," built by Scott's Shipbuilding and Engineering Company, Ltd., of Greenock, have been completed and commissioned. The main and auxiliary propelling machinery for both ships was supplied by Burmeister and Wain, of Copenhagen, and was installed to the specification and under the supervision of Mr. Sterry B. Freeman, the superintendent engineer of Alfred Holt and Co. We reproduce herewith, a photograph of the "Glenroy" taken during her recent successful trials on the Clyde. The ships have a service speed of about 18 knots in a fuly loaded condition, and an overall length of close upon 508ft., a breadth of 66ft., and a depth to the upper deck of 38ft. The measurement is between 9000 and 10,000 gross tons. In the six holds and 'tween deck spaces provision is made for about 653,000 cubic feet of cargo space. Large supplies of fuel oil, more than 1000 tons, can be carried in the double bottom tanks. Excellent accommodation for twelve passengers has been provided. The machinery, which is placed between Nos. 3 and 4 holds, comprises an arrangement of twin-screw, two-stroke, double-acting, six-cylinder oil engines with a bore of 620 mm. and a stroke of 1400 mm., and a total output for the two engines of about 12,000 S.H.P. There are four auxiliary generating sets, each consisting of an eight-cylinder B. & W. two-stroke engine, with poppet exhaust valves, running at 375 r.p.m. and driving a 300-kW 220-volt Laurence-Scott generator. The auxiliary equipment is very complete and is in accordance with the latest practice.

A New Anchor Liner

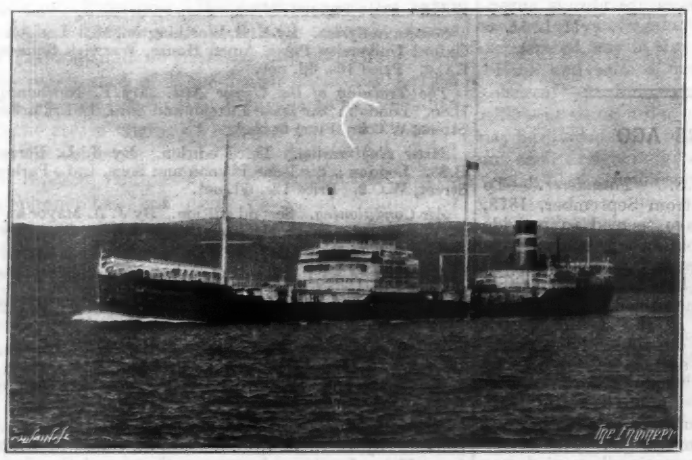
One of the outstanding motor vessels of the year was the twin-screw passenger and cargo liner "Cilicia," which was built for the service of the Anchor Line, Ltd., Glasgow. The ship, a photograph of which is reproduced on page 58, was designed specially for the firm's Eastern trade, calling at



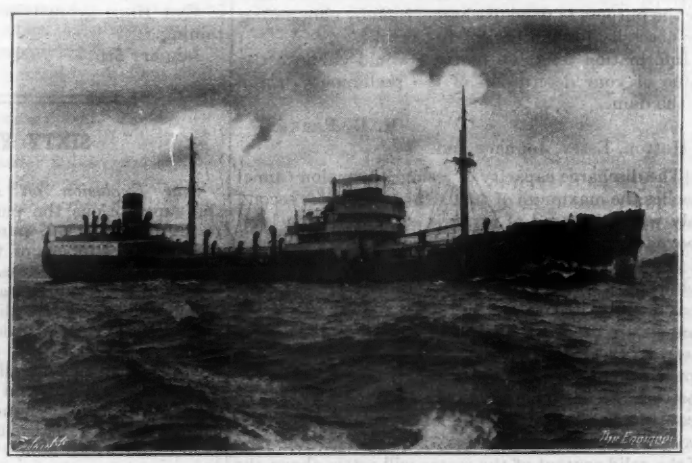
"DOMINION MONARCH" FITTING OUT AT WALLSEND-ON-TYNE



FIVE-CYLINDER 8000 S.H.P. OIL ENGINE FOR THE "DOMINION MONARCH"

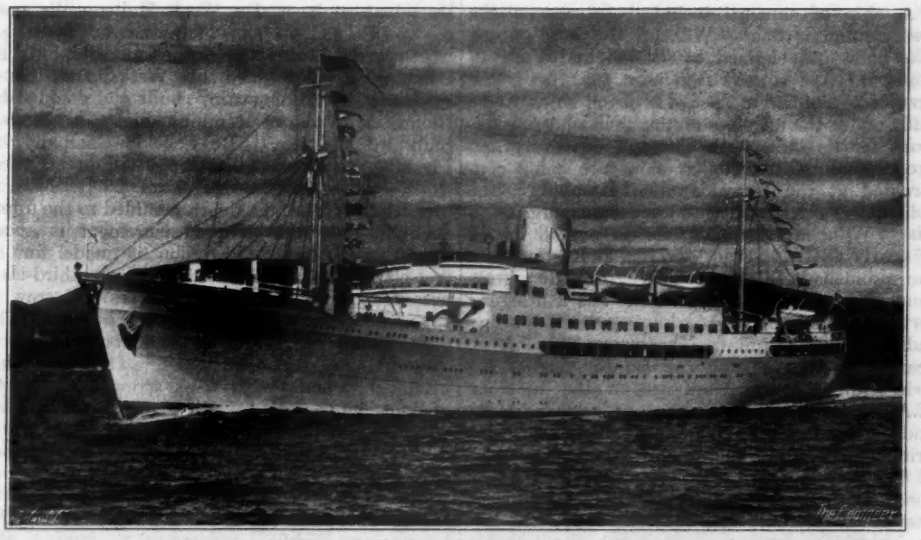


MOTOR TANKER "BRITISH FIDELITY"



STEAM TANKER "LA CARRIERE"

various ports *en route* to India, and was commissioned in the early part of the year. She was constructed and engined by the Fairfield Shipbuilding and Engineering Company, Ltd., of Govan, Glasgow, and her principal dimensions are as follows:—Length overall, 506ft.; breadth moulded, 66ft.; and depth moulded to the upper deck side, 35ft. 6in. Her loaded draught is about 27ft., with a gross tonnage of 11,200. Accommodation is provided for 321 first-class passengers. The cabins and public rooms are well laid out and the decoration is of a high order, and is specially suited to Eastern service.

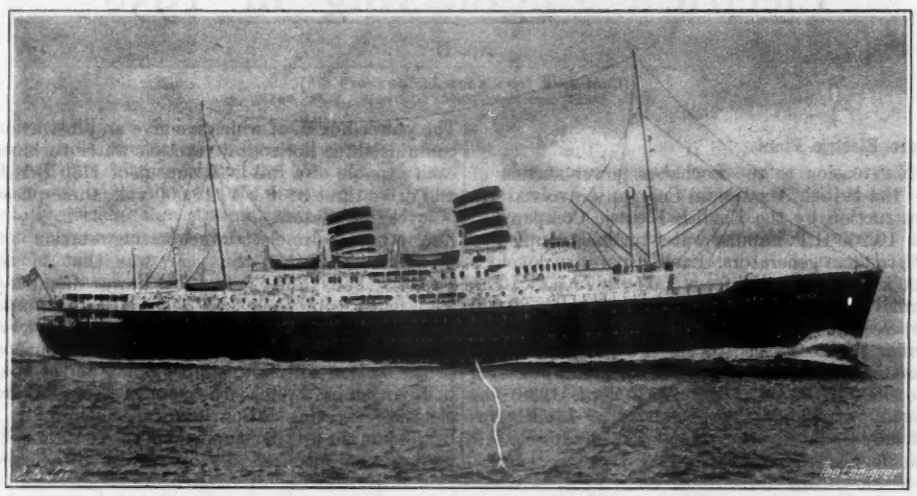


NORTH SEA MOTOR LINER "BLACK PRINCE"

The propelling machinery comprises a twin-screw arrangement of Fairfield-Doxford opposed-piston oil engines. Each unit has four cylinders with a bore of 725 mm. and a combined stroke of 2250 mm. The engines, which were constructed by the Fairfield Company, have a designed output of 11,400 S.H.P. at 120 r.p.m. All the deck and engine-room auxiliary machinery is electrically driven and the power is furnished by three oil engine-driven generator sets, an exhaust gas boiler taking the gases from one set of engines, with auxiliary oil fuel firing, providing the steam required for heating the passenger accommodation and for other domestic purposes.

Ellerman Line Cargo and Passenger Steamers

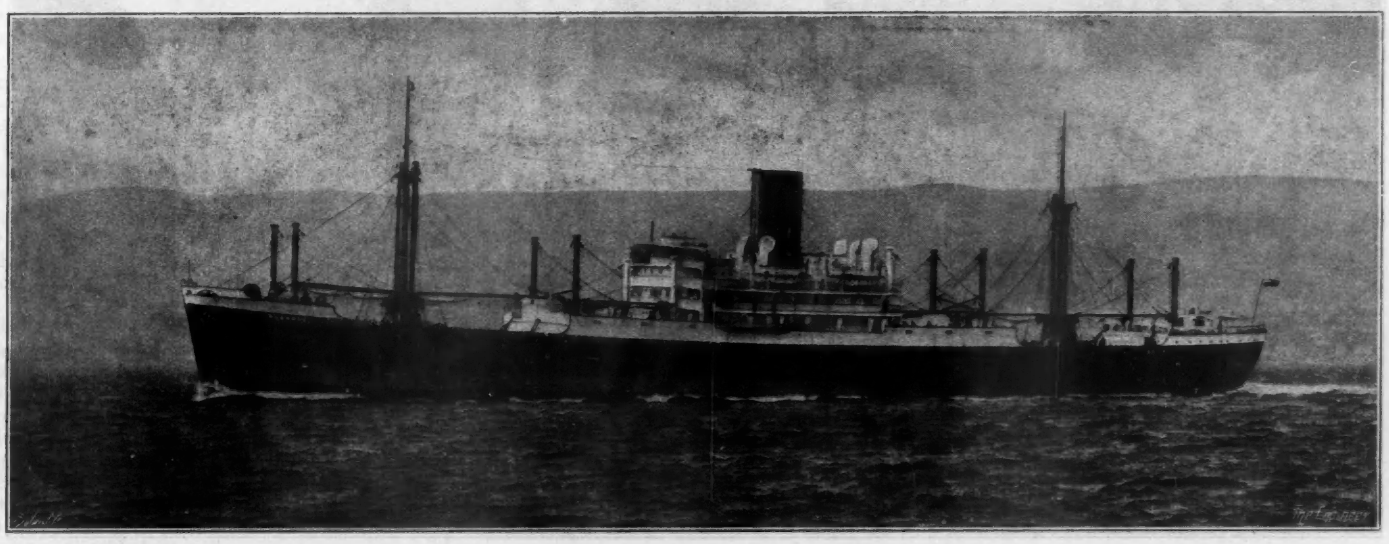
Representative cargo-carrying ships with passenger accommodation completed during the year were the two steamers "City of Lincoln" and "City of Edinburgh," which were constructed by Cammell Laird and Co., Ltd., for the service of Ellerman Lines, Ltd., between the United Kingdom and India, to the specification and under the supervision of Mr. W. Hinchcliffe, the owners' superintendent and naval architect. We show a view of the "City of Edinburgh" on page 58. The ships have a length between perpendiculars of 486ft., with a breadth moulded of 62ft., and a depth moulded to the upper deck of 35ft. The gross tonnage is 8046 with a maximum draught of 26ft. 6in. Six cargo holds are well arranged and are provided with derricks of the latest pattern, provision being made for the lifting of weights up to 45 tons. The accommodation for the four passengers and the officers is arranged below the bridge deck, the quarters of the crew being placed on the upper deck aft and in a deck house on the poop deck. The machinery comprises a twin-screw installation of Parsons impulse reaction single reduction geared turbines. Steam is raised in six single-ended multitubular type boilers with a working pressure of about 265 lb. per square inch. The boilers are equipped with Howden air heaters and smoke tube superheaters. The current for lighting and power is developed by three geared turbine-driven dynamos. Another ship built for the same owners was the "City of Karachi," a sister ship to the "City of Bombay." She was completed early in the year by Barclay, Curle and Co., Ltd. The length of these ships is 455ft., with a beam of 59ft. and a depth of 34ft., the deadweight carrying capacity being 9840 tons. A single set of Parsons impulse reaction geared turbine machinery is installed and steam is taken from four single-ended boilers, 15ft. 9in. diameter with a length of 12ft. 6in., with four furnaces arranged for oil or coal burning. The working pressure is 275 lb. per square inch, and the North-Eastern smoke tube superheaters are designed to increase the temperature of the steam by 180 deg. Fah. The engine-room auxiliaries are designed to work at full boiler pressure or alternatively at 120 lb. pressure, as may be required. In all these ships particular care has been taken to secure good engine and boiler-room ventilation.



NORTH SEA MOTOR LINER "VEGA"

Two North Sea Motor Liners

Among the outstanding motor vessels of 1938 mention must be made of the two express liners which are illustrated in accompanying engravings, and which marked a further advance in fast passenger and mail traffic between Newcastle-upon-Tyne and Norway. The "Vega" is a noteworthy addition to the fleet of the Bergenske Steamship Company, of Bergen, Norway, managed by the B. and N. Line Royal Mail, Ltd., of 25, Whitehall, London, and entered the company's service in June last. A full description of the ship and her machinery will be found in our issue of June 17th. She was built in Italy at the San Marco shipyard of the Cantieri Riuniti dell'Adriatico, and was engined at the company's San Andria Works. She has a length of 445ft., with a breadth moulded of 58ft., and a depth of 33ft., with a gross tonnage of 7500, and a service speed of 20½ knots, and is designed to carry 217 first-class and 248 second-class passengers. Ample accommodation for motor cars is also provided. The machinery comprises a twin-screw arrangement of C.R.A.-Sulzer engines, each with ten cylinders, having a bore of 650 mm. and a stroke



GLEN MOTOR LINER "GLENROY"

of 1200 mm. The service power is about 12,400 S.H.P. at 140 r.p.m.

Another equally important liner is the "Black Prince," of the Fred Olsen Line, which entered on her service between Oslo and Newcastle-upon-Tyne in May last, and was described in our issue of May 27th. She is the largest passenger ship to be built in a Norwegian shipyard, and has just been followed by a sister ship, the "Black Watch." Her length is 385ft. 9in., with a beam of 53ft., and a depth to the main deck of 30ft. 3in. Her measurement is 5200 gross tons, and she has a designed speed of 18½ knots. Her propelling machinery consists of twin-screw Akers-B. and W. two-stroke, single-acting oil engines. Each engine has nine cylinders, with a bore of 300 mm. and a stroke of 900 mm., the total output being 7000 I.H.P. at 145 r.p.m. Provision is made for 200 first-class and 50 second-class passengers, and excellent cabins and public rooms are provided. The ships were built and engined in Norway by the Akers Mek Verksted A/S, of Oslo.

Two Oil Tankers of 1938

Several additions were made to tanker fleets during the year, and British builders shared in these orders. In what follows we refer to two representative types of tanker, one propelled with oil engines and the other with steam machinery. The "British Fidelity"—illustrated herewith—was built at the Govan shipyard of Harland and Wolff, Ltd., for the British Tanker Company, Ltd., and with her sister ship, the "British Trust," completes eight similar vessels ordered by the company during the past three years. Her length between perpendiculars is 463ft., with a breadth moulded of 61ft. 6in. and a depth moulded of 34ft. She is designed for the bulk carriage of petroleum, and has a net tonnage of 4905, with a measurement of 8465 gross tons. The engine is a six-cylinder Harland-B. & W. four-stroke unit, of the single-acting crosshead type, with airless injection of fuel and underpiston pressure induction.

The oil tank steamship "La Carriere," which we also illustrate, was built by Swan, Hunter and Wigham Richardson, Ltd., to the order of Trinidad Leaseholds, Ltd., to the design and under the superintendence of the owners' consulting naval architects, Messrs. Jacobs Barringer and Garratt, of London. Her principal measurements are length 410ft., breadth extreme 53ft. 9in., and depth moulded 30ft. 9in. She has a summer freeboard draught of 25ft. 9in., and a measurement of 5685 gross tons with a loaded deadweight carrying capacity of 8540 tons. The pumping machinery is steam operated, as is the auxiliary and navigating equipment. The propelling machinery consists of one set of Wallsend Slipway vertical triple-expansion engines with cylinders of the following dimensions:—H.P., 26in.; I.P., 44in., and L.P., 77in., with a stroke of 48in. The engine takes steam from three multi-tubular boilers of the three-furnace type. They have a length of 11ft. 9in. and a diameter of 16ft. 6in., and a working pressure of 220 lb. per square inch. Superheaters of the R.B. Superheater Company smoke-tube type are fitted. The engine has a designed output of 3070 I.H.P. when running at about 80 r.p.m., and the loaded speed on the measured mile was 12·83 knots.

Noteworthy Passenger Liners Built Abroad

A ship of unusual technical interest is the German motor liner "Wilhelm Gustloff," which was built and engined by Blohm and Voss, of Hamburg, and is shown on page 58. She is the first of a number of special cruising ships to be built under the auspices of the Deutsche Arbeitsfront for its "Strength Through Joy" cruising programme. Other similar ships are being constructed at the Howaldswerke, Hamburg; the Schichau Yard, Danzig, and the Flensburg Yard. The "Wilhelm Gustloff" has an overall length of nearly 684ft., a beam of 77ft., and a depth to the promenade deck of 56ft. 7in. Her gross tonnage is about 24,000, and she has a designed service speed of about 15½ knots, with a cruising radius of 12,000 miles. The engines are of the geared type, two being coupled to each of the twin-screw shafts. They are of the builders' M.A.N. design, with a total output of 9500 S.H.P., and operate on the two-stroke, single-acting principle, having trunk pistons with a diameter of 520 mm. and a stroke of 700 mm. The engine speed is 220 r.p.m., and that of the propeller shafts 125 r.p.m. There are five 380-kW oil-engine-driven generator sets, and the exhaust gases are utilised in two oil-fired heating boilers. A feature of the hull design is the provision of outside cabins with two or four berths for 1405 passengers and for 426 officers and crew. In addition, some ten-berth compartments for youths are provided. Our illustration shows the smart appearance of the ship.

In last year's Annual Article brief mention was made of the new motor liners of the K.P.M., or Royal Packet, Company, of Amsterdam, which have been built to the designs of its naval architect, Mr. M. A. Cornelissen, and its superintendent engineer, Dr. W. J. Muller. We show on page 58 a view of the "Tegelberg," which was built by the Netherland Shipbuilding Company, and engined by Werkspoor. Sister ships are the "Boissevain," built and engined by Blohm and Voss, of Hamburg, and the "Ruys," built by the Royal De Schelde Company, of Flushing. Sulzer engines are fitted in all three ships. They have a length of 560ft., with a breadth of 72ft., and a depth moulded to the upper deck of 40ft. 6in. The measurement is about 14,150 gross tons. Provision is made for 82 first-class, 82 second-class, and 500 third-class passengers, giving, with the officers and crew of 231, a ship's complement of 895 persons. The designed service speed is 16 knots, which was exceeded on the trial runs. The propelling machinery comprises a triple-screw arrangement of eight-cylinder, single-acting, two-stroke engines, with a bore of 650 mm. and a stroke of 1200 mm., each engine having a designed output of about 3600 S.H.P. at 112 r.p.m. The particular lay-out of machinery adopted is claimed to give a lower engine-room than that possible with a twin-screw arrangement, while on parts of the run to the Far East one set of engines can be laid off, the remaining two then giving a speed of about 13 knots, which is sufficient for certain parts of the voyage.

(To be continued)

Electrical Engineering in 1938

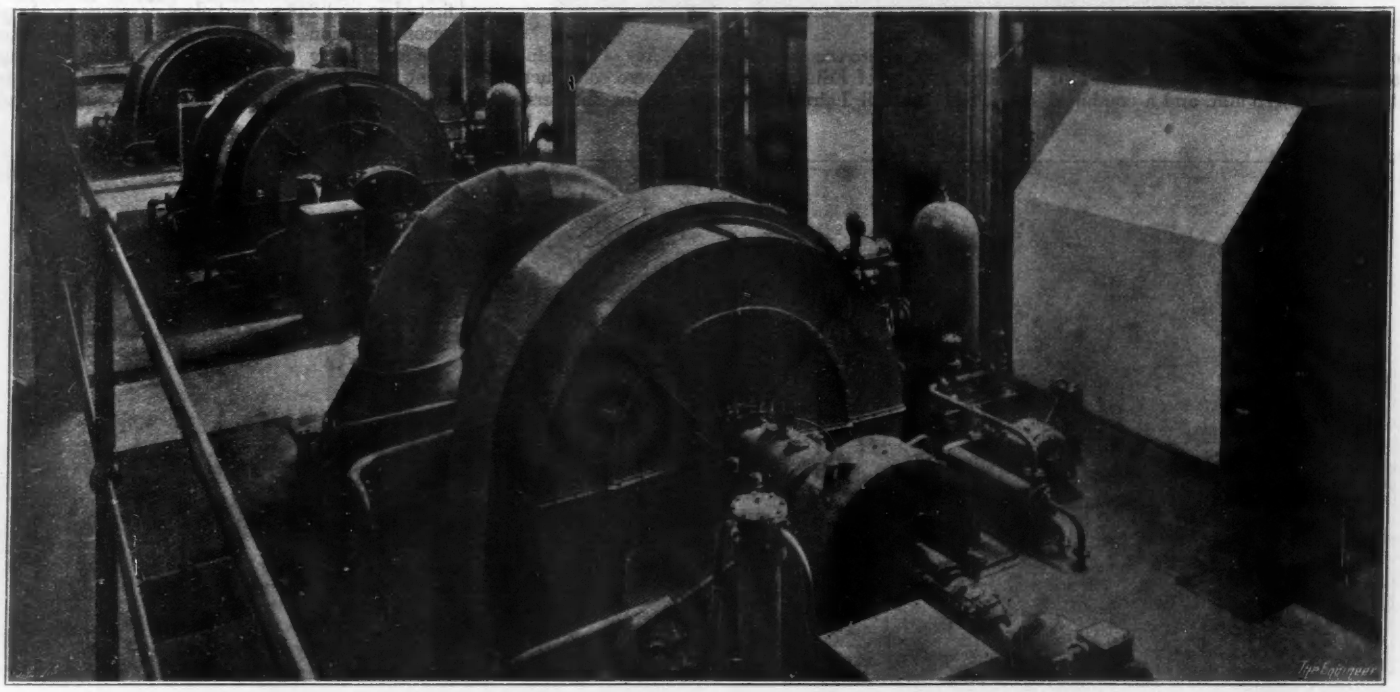
No. II

(Continued from page 34, January 6th)

Hydro Electric Plant

AN extension to the Lochaber power station of the British Aluminium Company involved the construction by the English Electric Company of five 10,200 H.P. impulse water turbines coupled to D.C. tandem generators. Each generator develops 3500 kW at any speed from 250 to 267 r.p.m. The normal current of each pair of machines is 20,000 amperes at 350 volts. These five units are similar to those constituting the original English Electric installation of 48,000 H.P., composed of five 9600 H.P. sets. On April 23rd, 1938, the Viceroy of India, the Marquess of Linlithgow, officially opened the Malakand hydro-electric scheme, North-West Frontier Province, India. The power-house, of which we give an illustration, contains three horizontal reaction water turbines, each capable of a full load output of 4750 B.H.P. and drive three 3200-kW, 11,000-volt, three-phase, 50-cycle alternators.

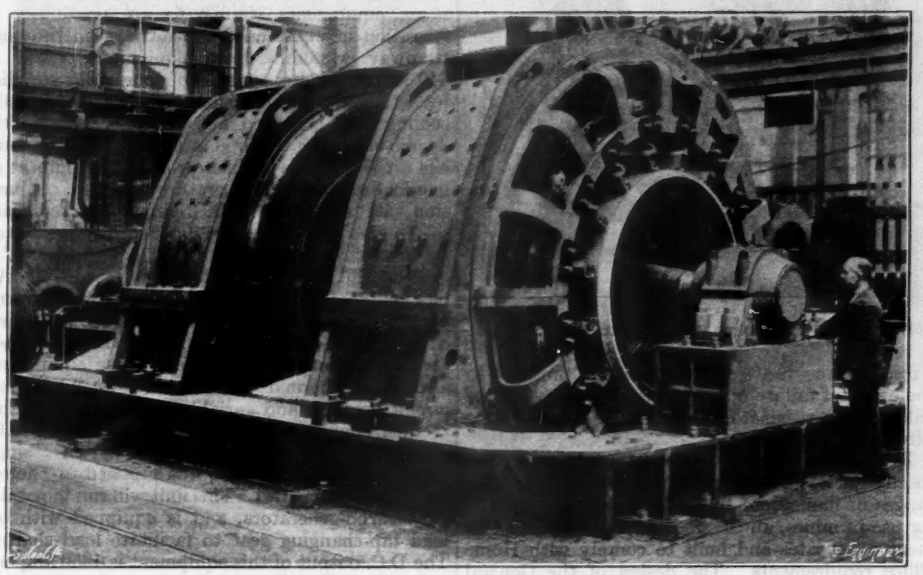
Another hydro-electric generating station put into service during the year was that of the Victoria Falls and Transvaal Power Company. The plant comprises two 1450 H.P. horizontal reaction turbines coupled to two 1250-kVA, 3300-volt, 50-cycle alternators. The chief purpose of the station will be to supply power to the town of Livingstone. Whilst this is only a small hydro-electric generating station, it is of special interest. It represents the first development of the Victoria Falls, and it is an automatically operated hydro-electric



THREE 4750 H.P. WATER TURBINE GENERATOR SETS, MALAKAND POWER STATION

plant. The turbines were started up by Sir Hubert Young, Governor of Northern Rhodesia, on March 16th, 1938. The English Electric Company's contract included the generating plant and switchgear. During the year the New Zealand Government placed a contract with the company for two water turbine driven generating sets for the Waitaki power station. The sets consist of two vertical shaft reaction turbines of 23,000 H.P. at 125 r.p.m., and two 16,666 kVA, 11,000 volts, three-phase, 50 cycles, vertical shaft umbrella alternators. Orders have also been received for small hydro-electric generating sets for installation in Australia and New Zealand.

The assembly on site by the Metropolitan-Vickers Electrical Company of a second 24,000-kVA vertical water alternator at Arapuni, New Zealand, was completed during the year and both machines are now in service. Three 12,500-kVA horizontal water wheel alternators of the same make were recently put into operation at the new Mettur power station of the Madras Government. Incidentally, when the station was flooded these machines were completely immersed in water, but suffered no injury. Two other 12,500-kVA machines were dispatched by the Metropolitan-Vickers Electrical Company to India for the extensions at the Pykara station of the Madras Government. Erection is also proceeding on a third 22,200-kVA generator at the Waikara Moana Station, New Zealand.



2750 H.P. WINDER MOTORS ON TEST BED

Rolling Mill Drives

A few of the more important electric rolling mill jobs can only be mentioned. Of the orders of the kind received by the British Thomson-Houston Company, that for the driving equipment for a hot aluminium breaking-down mill is worthy of note. The main drive will consist of a 1350 H.P. 40/51 r.p.m. reversing motor, capable of giving a peak output of 3250 H.P. The motor will be supplied from a fly-wheel motor generator set, consisting of a 1000 H.P. slip-ring induction motor, a 1190-kW D.C. generator, and a fly-wheel having a stored energy of 50,000 H.P. seconds. The B.T.H. Company is also supplying all the auxiliary motors and control gear for this mill. The order was received from the Brightside Foundry and Engineering Company, Ltd., makers of the rolling mill, and the equipment will be installed in the works of the Northern Aluminium Company, Ltd., Banbury. For installation at the same works there are being manufactured two 500 H.P., 490/980 r.p.m. D.C. motors, complete with contactor control gear, for driving cold rolling aluminium strip mills made by W. H. A. Robertson and Co., Ltd. In connection with a rolling mill electrification in the Midlands, the B.T.H. Company is manufacturing two D.C. motors, one rated 350 H.P., 150/300 r.p.m., and the other 300 H.P., 120/240 r.p.m. Several large motors were manufactured for a rolling mill in Australia, including a 1250 H.P., 428 r.p.m., 6600-volt, slip-ring induction motor for driving a hot sheet mill; a 500 H.P., 600 r.p.m., 440-volt, slip-ring induction motor for driving a cold rolling sheet mill; and a 250 H.P., 300/600 r.p.m. D.C. motor for driving a temper pass cold sheet mill.

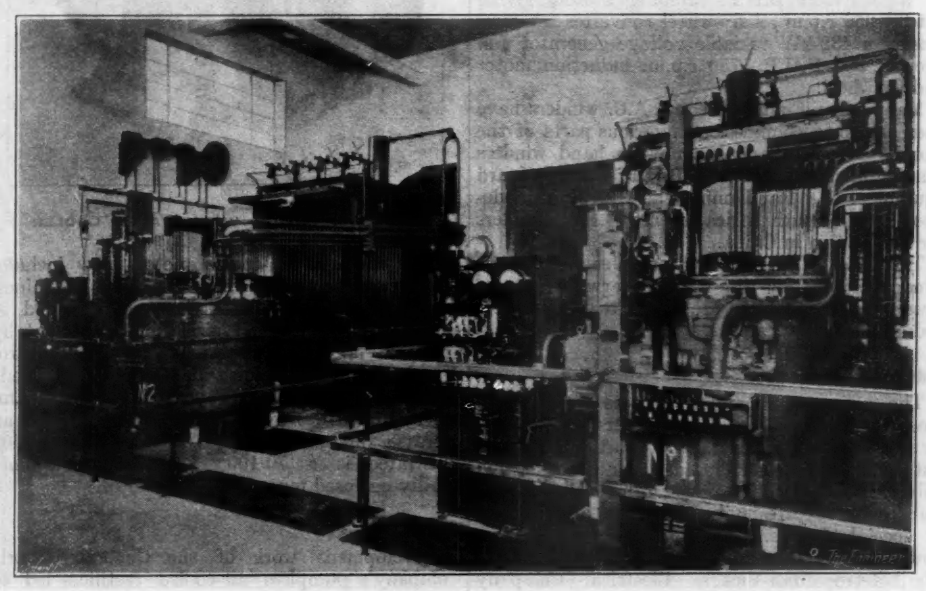
Some time ago H. A. Brassert and Co., Ltd., secured a large contract to erect a steel works at Karabuk, Turkey, and the B.T.H. Company was given the order for all the D.C. motors required. During the year about 150 of these machines, mainly special steel works motors, were completed, totalling over 5000 H.P. For the same installation a considerable quantity of distribution switchgear is also in course of manufacture. A number of other motors and motor generators ranging in size up to 1500 H.P. and 4000 kW respectively are nearing completion at Rugby, and will be installed shortly for various rolling mill drives. Many large rolling mill equipments were erected and put into operation during the year, one of the most notable installations being at the works of Richard Thomas and Co., Ltd., Ebbw Vale. Here the electrical equipment includes four 2500 H.P., 500 r.p.m., 11,000-volt synchronous motors for driving the roughing stands of a wide hot strip mill; a 600 H.P., 500 r.p.m., 440-volt slip-ring motor, driving a roughing scale breaker; a 700 H.P., 500 r.p.m., 240-volt D.C. motor driving a slab reducer; and two 200 H.P., 400/950 r.p.m., 240-volt D.C. motors driving edging stands. In addition to these four 1000 H.P. motors, one 400 H.P., and one 200 H.P. D.C. motors, together with a 3500-kW synchronous motor generator set, have been installed for driving a five-stand tandem cold strip mill.

An order received by the Metropolitan-Vickers Electrical Company is for a motor operating a bloom shear mill in Bengal. The normal rating of the motor is 700 H.P. and the peak rating 900 H.P. at 300/700 r.p.m., when operating at 500 volts D.C. An interesting feature of this equipment, which includes control gear, lies in the method of the control of the shear. The motor starts and stops for each shearing operation. It is designed with small inertia so that it will accelerate quickly from starting up to the time when shearing begins. After this point the motor field is strengthened to keep constant current, reducing the motor speed and increasing the torque. After shearing, the motor increases its speed on the return stroke to the maximum, and then slows down and stops at the end of the stroke. The whole operation is automatic. The company has installed several of these shears, all of which are operating satisfactorily.

The company is supplying a rolling mill equipment to the Broken Hill Proprietary Company of Australia, for operating its 18in. bar mill, which is at present driven by steam. The driving equipment consists of three 2000 H.P. normal and 4000 H.P. peak, 250/500 r.p.m. D.C. motors driving the three main stands; and one 300 H.P. normal and 600 H.P. peak, 300/600 r.p.m. motor, driving Edger rolls between stands 2 and 3. The motors are supplied with power by a motor generator set, consisting of one 5200 H.P., 740 r.p.m., three-phase, 25 periods, 6600 volts, slip-ring induction motor, driving three 1200-kW, 600-volt generators connected in parallel and arranged to share the load evenly between them. An exciter also forms part of the set for exciting the fields of the generators and mill motors. Control is carried out on the Ward Leonard system. Individual adjustment of the mill motor speeds is made by field control. The main rheostat is motor operated and fine speed adjustment is obtained by hand vernier rheostats.

A push bench equipment, constructed for Stewarts and Lloyds for South Africa, comprises one 1300 H.P. normal and 3200 H.P. peak, 250/500 r.p.m., 600 volts D.C. motor, driving the push bench. The motor is supplied from a motor generator set, consisting of one 1550 H.P., 740 r.p.m., three-phase, 50 periods, 2000 volts, slip-ring induction motor, driving a 1050-kW, 600-volt D.C. generator. In addition to these machines, smaller A.C. induction motors are being supplied for the drive of the polishing, sizing, and reducing mills, the mechanical press and mandrel extractor. An interesting feature in this mill is that the control gear is on the same principle as has been adopted for some time past in the company's reversing mill schemes. Control is obtained by special exciters which, by reason of their characteristics, serve to give the field forcing necessary to obtain quick acceleration and retardation, and also to limit the current peaks. Only one or two contactors are required. The acceleration is determined by the rate at which the field builds up, and retardation and stopping are initiated and controlled by a device comprising a pinion driven from the push bench gears which moves a rack carrying strikers. These strikers operate limit switches which control the retardation and stopping. By this method the push bench is stopped automatically and quite independently of the driver. In cases of emergency, however, the driver can stop earlier in the stroke if required.

The English Electric electric drives for the tandem continuous hot strip finishing mill, with mills of Davy United design, at the works of Richard Thomas and Co., Ebbw Vale, initiate a new type of production of steel strip and tin-plate by the continuous process. Together with mill



1000-KW RECTIFIERS IN THE PELAW SUB-STATION

and special constant-tension winding and unwinding drives for the skin pass mills and electrolytic cleaning lines, these drives represent an aggregate of over 100,000 peak H.P. of plant supplied by the English Electric Company.

For John Summers' new continuous Mesta sheet mill the company has in hand the whole of the hot mill main drives, together with the necessary 10,000-kW Ward Leonard motor generator sets. For the Lancashire and Corby Steel Manufacturing Company, and for the British Aluminium Company, the company has in course of completion reversing cold mills and skin pass mills for hot and non-ferrous work. Contracts received from the Empire include two large reversing mill equipments for blooming and rail mills for the new steel works of the Broken Hill Proprietary Company, Australia.

The Bengal Iron and Steel Company is installing two 20,000 peak H.P. reversing mill equipments for blooming and rail mills, together with D.C. and A.C. motors for merchant sheet mill and cold mill drives.

Electric Winders

Contracts for electric winding equipments in this country exceeded those of previous years. South African gold-mining activities also had a good effect on the electric winder business. Several orders were received by the Metropolitan-Vickers Electrical Company for equipments for this part of the world. Fully automatic operation is now adopted on all this firm's larger winders. An automatic Stubbs winder, installed in Lancashire, is said to be operating very satisfactorily with complete sequence interlocking. The system of dynamic braking for A.C. hoists developed last year is also said to be very successful, and new equipments were ordered for use in this country, Australia, South and West Africa.

The first Metrovick hydraulic coupling to be used on a haulage drive was put into operation during the year. Improvement in the coupling is said to have made very smooth control possible with heavy starting loads. This coupling replaces a mechanical friction clutch, which is liable to cause delays in consequence of maintenance work.

A considerable amount of electric winder work was also carried out by the British Thomson-Houston Company. Orders were received for several A.C. winder equipments for abroad, including one of 1370 H.P. and one of 500 H.P. for South Africa; one of 425 H.P. for China; and one of 120 H.P. for India. A 175 H.P. A.C. winder equipment was also ordered for a colliery in Warwickshire. All these are standard equipments. Constructional work was carried out on two 1537 H.P. Ward Leonard winder equipments for Rand Mines, Ltd., South Africa. Both will be used for winding loads of 10,000 lb. net from a depth of 6250ft. at a speed of 2000ft. per minute. Each equipment includes a motor generator set, Ward Leonard control gear, and the B.T.H. system of controlled emergency regenerative braking.

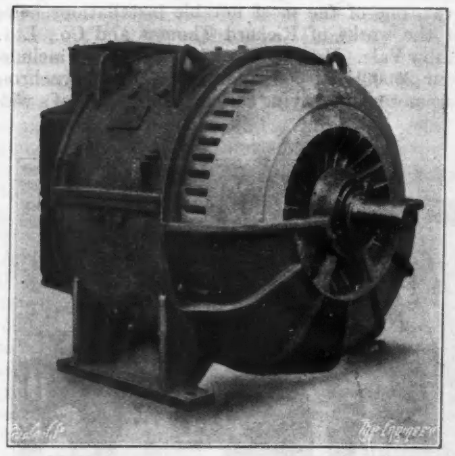
Among the English Electric winders put into service were two Ward Leonard Ilgner equipments for Taquah and Abosso Mines, Ltd., and two for Amalgamated Banket Areas, Ltd. They were ordered by the New Consolidated Gold Fields, Ltd. The equipments are similar in all respects, except for the supply voltage. Each equipment consists of a 580/1250 B.H.P. winding motor, giving 0 to $\pm$250 r.p.m., a fly-wheel converter set comprising a 432-kW variable voltage generator and exciter, 500 B.H.P., 750 r.p.m. induction motor and fly-wheel.

Many other English Electric A.C. winders have been put into commission in various parts of the world. The company has now in hand winders ranging in size from a 3140 B.H.P. Ward Leonard equipment for Rand mines at Durban Roodepoort Deep, South Africa, to 120 B.H.P. winders for installation in China.

Two 2750 H.P. D.C., 67 r.p.m. General Electric winder motors for the West Spaarwater Anglo-Transvaal Consolidated are illustrated on the test bed at the maker's works.

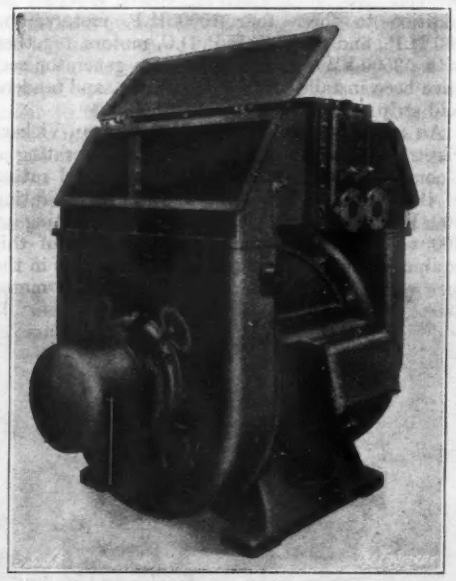
Industrial Motors

The policy of supplying motors designed to meet specific requirements was pursued, notably by Crompton Parkinson, who, during the year, put forward a series of standard machines costing only a little more than general-duty motors, yet embodying features only obtainable in the past in special designs. "Minor" fractional horse-power motors were also developed by this firm. The Metropolitan-Vickers Electrical Company introduced a heavy-duty motor for scraper haulage and similar service and a tandem lift motor. Where A.C. motors for high-speed lifts with low-speed levelling are desired, the latter machine offers an alternative to the A.C. commutator motor. The range of motors with water-cooled air coolers, as illustrated, was extended. Where air pipe connections cannot be conveniently made, these machines provide a satisfactory alternative to forced ventilated machines. They are claimed to be particularly advantageous in an enclosed space where it is essential to prevent an appreciable rise in the temperature of the ambient air produced by the heat generated in the motor. In the event of failure of the water supply the motor will operate satisfactorily with the air duct covers lifted.



70/100 H.P. ENCLOSED FAN-COOLED D.C. MOTOR

Bruce Peebles and Co., Ltd., introduced new totally enclosed fan-cooled A.C. motors, also new ranges of flameproof totally enclosed A.C. motors for use in mines, all covered by the Mines Department certificates and built to comply with Home Office requirements. The design of the General Electric Company's A.C. totally enclosed fan-cooled motors above 50 H.P. at 1500 r.p.m. was improved. While retaining the double air circuit, which is desirable in larger machines, the stator is exposed to external air, thus giving more effective cooling. The standard range of A.C. totally enclosed fan-cooled motors now includes flange-mounted and vertical-spindle machines. Smaller flameproof motors have been added to the range. Additional sizes of G.E.C. totally enclosed, fan-cooled, D.C. machines were introduced. The range of this type of machines extends from 3 H.P. at 1000 r.p.m. to 150 H.P. at 350 r.p.m. An improved design of diaphragm has led to an increase in efficiency. The G.E.C. machine illustrated is a 70/100 H.P., 369–750 r.p.m., totally enclosed fan-cooled D.C. motor.



1000 H.P. MOTOR WITH WATER COOLER

Rectifiers

Development work of the General Electric Company's pumpless air-cooled rectifiers led to beneficial results. Outputs of 500 kW at 600 volts, 1000 kW at 1500 volts, and 1500 kW at 3000 volts are easily obtained in single cylinders. Units of these ratings have been subjected to severe overload and short-circuit tests under controlled conditions. The ventilating system of the rectifier was simplified, and the power required to drive the fans reduced. Air-cooled rectifier equipments were installed in Australia, China, India, and on the Continent of Europe. Units were built for collieries, steel works, textile mills, chemical works, printing works, and multiple stores. An important contract for this class of plant was placed by London Transport. It includes eighty-eight rectifying units with a total output of 37,000-kW, 22,000-volt stonework cubicle switchgear, twenty-two transformers of 2000 kVA, over eighty high-speed circuit breakers, D.C. switchgear and all auxiliary equipment for station lighting, local power supplies, &c.

A considerable demand was experienced by the British Thomson-Houston Company for glass bulb rectifiers. One of the 1938 installations comprises seven equipments similar to six previously in operation in unattended sub-stations on the same tramway system. Each equipment, rated at 840 kV, 525 volts, consists of four bulbs supplied by a twelve-phase transformer. The speed of the cooling fans is varied automatically to give the degree of cooling required at each load. Each bulb has a thermal relay which protects the bulb at all overloads and air temperatures, and in conjunction with a high-speed D.C. circuit breaker, these relays give full protection against sustained overloads or short circuits.

Two B.T.H. equipments, each rated 750 kW, 600 volts D.C., and designed for unattended operation under the control of a supervisory system, were supplied to the Australian General Electric, Ltd., for the Brisbane City Council. These equipments also have thermal overload relays, high-speed circuit breakers and variable-speed fans. Another rectifier equipment rated 1000 kW, 230 volts D.C., consisting of twelve bulbs supplied from a single twelve-phase transformer, was supplied to Thomas Bolton and Sons, Ltd. This unit will run in parallel with turbo-generators, and is equipped with on-load tap-changing gear to facilitate load sharing. The D.C. output of this equipment is 4350 amperes continuously, reaching 8700 amperes momentarily. Seventeen glass bulb rectifier equipments, similar to twenty already in operation, were delivered to Odeon Theatres for power supply to the projector arcs. Each equipment includes two bulbs, which normally work together as a six-phase rectifier, but the equipment will also operate at full output as a three-phase rectifier, with only one bulb in operation. Remote control is provided by a push-button in the operating room. We illustrate on page 65 two B.T.H. 1000-kW steel tank rectifiers in the Pelaw sub-station on the South Tyneside electrified lines of the L. and N.E. Railway.

Considerable progress was made by Bruce Peebles, Ltd., in connection with the fifth rectifier contract for the Southern Railway for fifteen 2500-kW grid controlled rectifier equipments for its main line electrification schemes. When this order has been completed, the firm will have supplied 115 rectifier equipments to this railway, with a total output of 287,500 kW.

Among the important rectifier orders received by the English Electric Company was one for twenty-one 1500-kW steel tank units for the London Passenger Transport Board for use in connection with the electrification of the northern and Elstree extensions of the Board's North London Line.

(To be continued.)

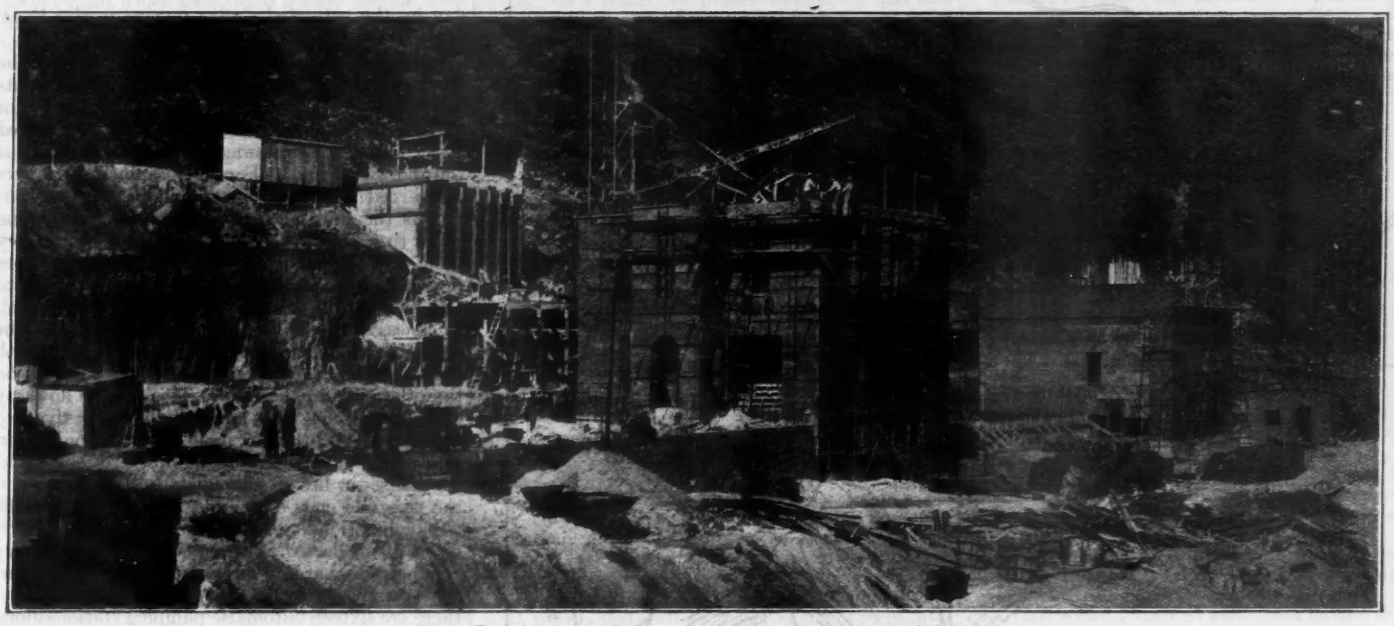
FIBRE CORES FOR COLLIERY WINDING ROPES.—The question of the effect of internal corrosion and corrosion fatigue on the ultimate life of colliery winding ropes and the part played by fibre cores in internal corrosion, have been discussed in papers issued by the Wire Ropes Research Committee of the Safety in Mines Research Board. In a recently issued publication there are given the results of a further investigation made with the object of trying the effects of the various alternative materials which might be used for the manufacture and lubrication of the cores of winding ropes and thus arriving at a more precise definition of the properties of a satisfactory core. This investigation was mainly directed towards the development of methods for preventing internal corrosion owing to the fibre core. It was found that the hard "leaf" fibres, manilla, New Zealand, and sisal hemps are suitable for these ropes in so far as their mechanical properties are concerned. Jute is considered unsuitable, because of its lack of durability and coir because of its compressibility. New Zealand hard fibre appeared to be the best of the hard fibres. The presence of a thin mineral batching oil reduces the capacity of the core for holding lubricant, and it is suggested that a soap solution should be used. Experiments suggested that asphaltic lubricants are preferable to petrolatum or soap thickened greases, because of the way in which they are retained in the core.

Water Supply & Sanitary Engineering in 1938

No. I

FOR many years we have, at this time of the year, reviewed the work that was being done during the past year in the various parts of this country and abroad for water supply and sanitary purposes. We do not intend on this occasion to omit that review. But since a number of large schemes were in hand abroad during the year, we intend to preface our review with some account of them, reserving attention to British and other foreign schemes for the next issue.

Perhaps the most impressive of the schemes upon which work was still in progress during 1938 is the great Ward's Island sewage works at New York, illustrated by an accompanying half-tone engraving. This plant cost approximately 30 million dollars and is capable of handling 190 million gallons per day of raw sewage by the activated sludge process. Up to 1935 most of the sewers of the city had their outfalls directly through the water fronts into the tidal waters that flow in and about the city. As the amount of sewage discharged increased, the conditions of the water, particularly in the inner harbour, became progressively worse. Investigation revealed that as many as twenty days might pass before the whole of any given sewage discharged was removed from the harbour. In consequence of that state of affairs solids were deposited and decomposition, ebullition of gas, blackening of the waters, and the inevitable nuisance resulted. In 1935 there were sixteen sewage plants treating the flow from one-sixth of the population, but less than 3 per cent. of the sewage finding its way to the inner harbour had been passed through fine screens. The Ward's Island plant is designed to have an eventual capacity of 426,000,000 gallons per day and is situated close to the populous sections of Manhattan and the Bronx. On the Manhattan side sewage is collected from fifty-two outlets, which previously discharged directly into the river, by an intercepting sewer 6¾ miles long, serving an area of 3252 acres with a population of 615,000 people. On the Bronx side the intercepting sewer, 2½ miles long, collects from eight previously existing outlets and serves an area of 4468 acres with a population of 553,000 people. The sewage after passing through grit chambers, is carried to Ward's Island through two tunnels. That from the Bronx is 5630ft. long, 10ft. 6in. diameter, and is



KLOOF NEK PURIFICATION PLANT, SOUTH AFRICA, UNDER CONSTRUCTION

WARD'S ISLAND SEWAGE DISPOSAL WORKS, NEW YORK

situated 150ft. below the waterway. It was intended that the Manhattan 8ft. 6in. tunnel should be 300ft. down. But while boring was in progress a fault zone of crushed rock was encountered under the river, and it was found necessary to go down another 220ft. to avoid it. This tunnel is 3392ft. long. Treatment is given at the works in preliminary settling tanks, aeration tanks, and final settling tanks, and the resulting sludge is carried out to sea in ships specially built for the purpose.

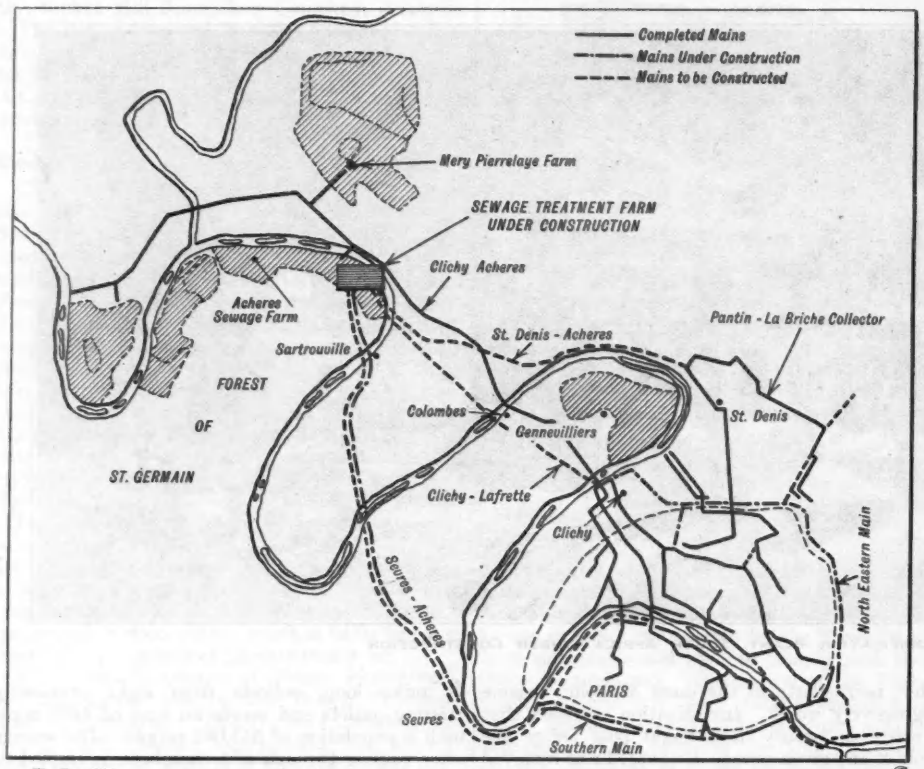
The city of Durban, in South Africa, is notable for having large-scale water supply and sewerage schemes in progress simultaneously. The sewerage scheme owes its inception to the energy of Mr. W. M. Campbell, the City and Water Engineer, who caused the requirements to be investigated and submitted a report on his findings to the Council. The city falls naturally into a southern and a northern drainage area, and he suggested four alternative schemes for the first, and five for the second, giving his personal recommendation to one of each. The Council accepted these recommendations and work is now in progress on the schemes, which in aggregate are likely to cost about £1,500,000, spread over a period of ten years or so. The southern area, upon which work is proceeding the more rapidly, is to have two sewers converging to a pumping station, whence their combined flows will be pumped to the outfall works. Here the sewage will be screened and put into storage tanks ready for discharge to the ocean on outgoing tides through a 6ft. by 4ft. tunnel under Bluff Ridge and a 45in. diameter outfall pipe extending 200ft. under water out to sea. The sewage from the northern area will be discharged partly to sea through an outfall at the north pier of Durban Bay harbour and partly through a treatment works situated to the north of the city, which is to discharge into a suitable stream about 100 yards above its outfall into the ocean.

In the same Dominion a great work is being pushed forward at Cape Town. For many years the colour of the water supplied to that city was a cause of great complaint, but nothing was done to alleviate the trouble. The water was not only badly coloured, but was liable to some pollution in times of heavy rainfall and was also actively corrosive, so that the cost of maintaining and replacing 700 miles of water mains amounted to as much as £20,000 per year. Three or four years ago an experimental purification and clarification plant was put into operation, and the results obtained were so satisfactory that it was decided to erect a larger plant. The Kloof Nek purification plant, under construction during the year, is illustrated in an accompanying engraving. When completed, it will have a capacity of 3,000,000 gallons per day, and will be able to carry an overload up to 4,000,000 gallons per day. The raw water entering the plant receives first of all a lime dose at the rate of 0·20 grains per gallon, followed at a second measuring weir by a similar dose of alum at the rate of 1·8 to 2·0 grains per gallon. It then flows to a mixing chamber, 11ft. square by 12ft. deep, fitted with mechanical agitators, followed by sedimentation tanks, 130ft. long by 35ft. wide by 10ft. 6in. water depth. The inlets and outlets are at the same end of each tank, and there is a dividing wall. The tanks are designed to provide five hours' retention. Following the tanks there are six filters, 20ft. by 13ft. 2in., capable of passing 500,000 gallons per day each. The arrangement of the filtering medium is of interest. There are 2in. of sand 30/40 mesh, 3in. 20/30 mesh, 3in. 10/20 mesh, followed by 3in. of material, one to ten to one to four, and 4in. one to four to one to two. Final adjustment of the exact arrangement of the filtering medium has not yet been reached. Thence the purified and clarified water flows to the storage reservoirs for the supply of the city.

Nearer home, there is in process of construction a system of sewers for the suburbs of Paris. The preparation of the plan for collecting the sewage from all the communes around the city was initiated by the General Council of the Department of the Seine as far back as 1927. The situation of the collecting mains is shown on an accompanying map. As an example of the kind of work involved mention may be made of the Sèvres-Achères main begun in 1935. It is to a large extent being driven in tunnel as much as 300ft. underground. Near Sartrouville, in the bend of the river Seine, borings revealed a layer of sand overlying a bed of clay, and water rose in the bores to the surface. To deal with work in this area, where compressed air will, of course, have to be used, a reinforced concrete shaft was being sunk during the year. It is 23ft. diameter and 1 m. thick at the bottom. At its top the outside diameter is increased to form a flange on which the whole shaft is supported. Similar, but less serious difficulties have been encountered elsewhere. Concrete for all the mains is mixed and prepared at a central plant in a gravel pit near Sartrouville, and carried by lorries to the points of use. The sewage reaching Achères when the mains are completed will be partly treated on existing farms shown on the map. But a treatment plant to deal with 200,000 cubic metres per day by the activated sludge process is also to be erected.

A sewage disposal plant completed during the year at Winnipeg is said to be the largest of its kind in Western Canada. The city stretches for 10 miles or so along the western bank of the Red River and the new sewage works are situated at the northern end. Formerly numerous sewers discharged directly from the city into the river. It was therefore necessary to lay an intercepting sewer to collect the various discharges and convey them to the treatment works. This sewer varies in diameter from 3ft. 6in. at its furthest point to 7ft. 6in. at the treatment plant, and has a wall thickness of 8in. to 1ft. Besides the flow from the city the treatment plant is designed to deal with sewage from St. Boniface and other suburbs on the other side of the river. This sewage flows by gravity through eight pipes under the river to chambers beneath the main intercepting sewer, into which it is lifted by pumps. As the intercepting sewer lies at some distance from the river, the riverside ends of the old sewers sloped in the wrong direction. Sewage from this area had therefore to be collected in a number of new subsidiary channels discharging to points below the interceptor and is pumped thence into it. Altogether there are sixteen automatic pumping stations along the length of the interceptor, which is 7½ miles long and is designed to carry 160 million U.S. gallons per day to the treatment plant. The latter is a primary sedimentation plant, so arranged that secondary treatment works can be constructed as soon as it is deemed necessary to have them. The main interceptor sewer discharges into a 32ft. diameter surge chamber, 52ft. below ground. The sewage is lifted by pumps to ground level and, after passing through a tunnel, reaches the grit chambers. It then flows to two settling tanks, 115ft. diameter by 12ft. water depth, in which 55 per cent. of the organic matter is deposited and removed by a mechanical scraper. The effluent overflows the edges of the tank and passes directly to an outfall into the river. The sludge is pumped into four concrete digesters, 60ft. diameter by 25ft. deep, in which it remains for fifty days. The gas resulting from digestion is at present used only for heating purposes, but it is envisaged that it will sooner or later be used for power generation. From the digesters the sludge passes to elutriation tanks, 22ft. diameter by 10ft. deep, where it is washed with water, and then to a mixing tank, where an iron salt is added to facilitate filtration. After filtration to remove the excess water the resulting sludge cake is stored. It is intended to sell this product if buyers can be found.

(To be continued)



PARIS SUBURBAN SEWERAGE SCHEME

The Development of High-Speed Craft*

By H. SCOTT-PAINE

No. I

THE development of high-speed motor boats with which I have been associated is a subject upon which it is not easy to prepare a lecture of the type and magnitude really suitable for a Thomas Lowe Gray Lecture. The difficulty lies mainly in the acknowledged fact that this development has not been along conventional lines, by a series of systematic steps advancing from well-established practice and under the direct guidance of scientific theory, or even of tests of the usual scientific nature. The development as I know it has arisen mainly from my own rather unusual personal experience in racing boats and in handling fast motor boats in heavy weather.

Although the early stages, at any rate, might be described as highly empirical, there can be no doubt that the result has been designs having performance and sea-keeping qualities at high speed far ahead of any others of which I am aware.

My own experience commenced in 1906, when I built a canoe and fitted it with a motor cycle engine, and right from that time onwards each development has been based upon what I judged to be best, in the light of the continual personal experience of handling each experimental type with my own hands and under the most exacting conditions which I could find.

Experience in designing, building, and racing "Miss Britain III," with its Napier "Lion" engine, with which I still hold the salt water speed record, taught me a great deal. My long experience with

* The Eleventh Thomas Lowe Gray Lecture. The Institution of Mechanical Engineers, January 6th.

early aircraft also taught me, as nothing else could, two vital lessons. One is the great importance of saving weight in every detail; the other is of even greater importance. It is the arranging of trials of such realistic thoroughness that conclusive results are reached quickly, and the taking of so intimate a personal part in these trials that one learns by personal judgment, in character almost artistic perhaps, where the limitation lies and what is the next proper step to take.

It is also natural that these designs have not been accepted with immediate admiration by engineers and constructors, whose experience has been based upon step-by-step improvement by methods governed mainly by the serious consequences of failure to fulfil estimated performance or reliability.

How can I well describe to you these steps of development which were taken mainly because I felt they were right, and how can I show you characteristics which can only be really demonstrated at high speed in bad weather?

From the earliest days of my investigation into mechanically driven displacement ship hulls, I divided them into two classes :—

(1) The weight carrier.
(2) The speed type.

I am convinced that the mechanically propelled displacement hull of to-day has grown from the sailing ship of yesterday, and that the speedier type of steamship of to-day possesses its depth of hull in the water because it follows the sailing ship design. The years of thought, invention, and imagination that followed the installation of the first steam engine in a sailing ship hull, produced only one line of development until the beginning of this century, when a departure was made by those great engineers who evolved the torpedo boat, which in 1900 was capable of 36½ knots, a speed which has only been increased in the succeeding thirty-eight years to 40 knots. I could find no other real novelty in hull shape which promised any great increase in the speed of water transport. Hence, if any field for development existed at all, it was a large one.

From early days a great deal of practical thought was spent on the sailing ship, an element of technical design being intermingled with practical construction in the eighteenth and nineteenth centuries. A revolution in design was brought about by the necessity of sailing the ship into the wind, which demanded considerable keel or side area to prevent it making leeway. So the sailing ship developed depth in the water for this purpose. The ability to carry more load was an incidental advantage.

The introduction of mechanical propulsion was long combated, on the one hand by the practical sailor, who was loath to rely on the newly produced steam engine, and on the other by the shipbuilder, whose masts, spars, and sails would, he feared, no longer be required. Such were the advantages, however, from the transport point of view, that the engineer persisted until these obstacles were finally overcome, and to-day, to all intents and purposes, there are no sails left. The engineer, however, was, and still is, controlled by the principles of hull design which were established by the sailing ship. The "Queen Elizabeth," the "Hood," and the latest destroyers are thus to a great extent modelled on the nineteenth-century sailing ship.

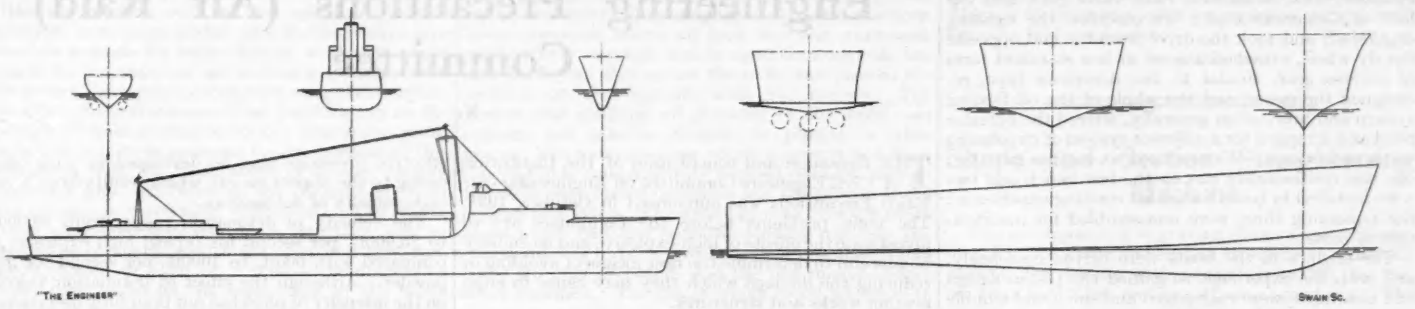
The basis upon which I developed my ideas for the design and building of faster hulls was not that of the sailing ship, but of a much earlier type—the catamaran outrigger-balanced surface canoe, which long ago sailed as fast before the wind as almost any boat of the present day. From experience gained as a boy in building and steaming model boats, I had discovered three factors which were essential to obtain increased speeds :—

(1) Lightness of structure.
(2) Narrowness of beam.
(3) A very shallow draught.

The weight carrier did not interest me, but the possibility of building a speedier type of hull that could be economically used was my immediate concern.

As a commencement I decided to try to design a type of small launch or boat for pleasure or industrial purposes faster than those already in existence. In my own mind, I had the possibility of larger fast boats clearly before me, but I felt convinced that their development would naturally follow the smaller boat, if successful, and was content to concentrate at first on the latter. This intention had been in my mind for seventeen years, and the accumulation of practical experience gained from continual association with the machinery of aircraft, steamships, boats, motor cars, and tanks, together with my experience with small motor boats, sailing boats and flying boats, encouraged me to try to carry it out.

I purchased a shipyard that had been a flying boat factory during the war and commenced to establish order and cleanliness amidst the chaotic untidiness and dirt which always seems to be associated with shipyards. I employed boat-building craftsmen, but found them so saturated with shipbuilding tradition that they would not alter their ways and engage themselves on new ideas. I used the method of persuading the men that the ideas were theirs and not mine, but I found the human element of this new venture more difficult and trying than any other part. It took literally years to settle down, and I am afraid that during that period we earned the name of the "Hire 'em and Fire 'em Yard"!



COMPARISON OF ROUND-BILGE AND HARD-CHINE FORMS OF HULL

An examination of the small fast hulls then in existence showed that the hydroplane was the fastest of all known designs, but this was unusable in bad weather. Of the remainder, the double-wedge or hard chine boat was the best, in my opinion, although I carefully examined, and in some instances built and tried, the sea sled craft and other highly experimental types, which I eventually rejected as being unsuitable for various reasons.

I believe I am correct in saying that the hard chine boat had up till then proved most difficult to drive and most unreliable. I had been associated in 1910 not only with their racing but also their building. To drive one of these boats was an adventure necessitating a life jacket, as they capsized easily. They were untouched by any development during the immediate pre-war period, being designed, with possibly very few exceptions, for purely sporting purposes.

During the war, however, and afterwards, the Americans had fostered the hard chine boat and had to a large extent eliminated its most pronounced faults. The great disadvantages still associated with this type of hull in, shall we say, the 1924–26 type of American hard chine boat, were :—(1) The pounding or slapping caused by the hard riding of the fore body; (2) the high angle of attack of the hull under way, owing to the arrangement of its trim angle, so that as much boat or hull was pushed out of the water as possible, leaving as little wetted surface as was necessary to carry the load of the boat; and (3) the pitching or diving of the boat when the throttle was closed, which caused the bow to dive and the stern to rise. The effects of these disadvantages are apparent from the fact that in bad weather it was highly dangerous to run into a head sea, because it might be absolutely necessary to close the throttle, with the result that the boat's head dropped and dived into the head sea. Moreover, the high trim angle of the boat, even in comparatively smooth weather conditions but with a broken sea, made the riding extremely uncomfortable. Pounding or slapping affected the planks, frames, and structure of the fore body generally, and only relatively large boats could be used in anything but reasonably fine weather. A point of equal importance was that whereas at high speeds, with only a small proportion of the hull in the water, the rudder was quite efficient, it became almost ineffective when the speed was dropped and the whole of the boat was in the water. In bad weather and at slow speeds therefore a loss of directional control was apparent.

Apart from these defects, the American boats were far in advance of those that had been produced anywhere else, and tribute must be paid to their builders for a great advance in small boat design.

From this it will be realised that a hull had to be designed which could be steered at all speeds in all conditions of sea. It was essential to keep the size of the rudder as small as possible to reduce resistance, to find some method of minimising or eliminating the slapping or hard riding, to produce a seaworthy hull with reliable helm control in bad weather, and to prevent the diving of the boat when closing the throttles.

Another matter as important as the construction of a successful hull was the machinery to propel it, and at that time there were, in my opinion, no suitable engines either in England or on the Continent. There was one suitable marine engine in America and two or three motor car engines that had been converted to marine use, for which purpose, it was thought in this country, they had been fitted simply with a reverse gear-box with no other major modifications. The English marine engine manufacturer dismissed the American engine lightly and refused to contemplate anything like it; he insisted upon the necessity of a heavy cast iron engine, and nothing would alter his views. The question of price had also to be considered, as the American engines cost 50 per cent. less than ours and averaged about 8 lb. weight per horse-power; thus an American power plant of 100 H.P. weighed well under 8 cwt., whereas the corresponding British engine was so much heavier as to be entirely out of the question for this type of craft.

I found here, as I had discovered in America, that the conversion of a motor car engine for marine use was not a simple affair. The automobile engineers of Detroit, where probably the greatest concentration of light internal combustion engineering is centred, had encountered numerous and unexpected difficulties which they had not previously experienced with motor car engines.

It became apparent to me that in this new branch of light marine engineering the operating conditions resembled in all practical respects the engine duty in aircraft which I knew so well—both having to take far more difficult loads than in any other mode of transport. Just as the aero-engine has "collar" work of the heaviest nature and must be completely reliable (something not understood by many engineers), so the marine engine has a continuous collar load, and although the consequences are not so serious as those attaching to failure in the air, absolute reliability is demanded. It was discovered that an ordinary motor car engine, reliable for any kind of road work, suffered a series of failures directly it was installed in a boat, due to the severe conditions. In a road vehicle the frequent closing of the throttle affords relief that enables it to escape damage.

I made a number of trips to the United States and found the American engineers frank and helpful as they generally are, and I returned convinced that their marine engines were by no means casual conversions but had been seriously and scientifically carried out. Generally speaking, those American engines, which I did not hesitate to use in the earlier days, gave good service and were first class.

Returning to the problem of boat design, I should explain that as in the design of aircraft it is the use of dihedral angle which is mainly responsible for lateral stability, so in the design of my own boats it is the variation of dihedral angle along the length of the hull which is the main factor in affording satisfactory control at all speeds, with a rudder of reasonable size. This was one of the essential facts that I realised almost wholly as a result of the careful and critical handling, personally, of flying boats and successive experimental boats.

Briefly, I rearranged the underwater form of the boat so that the trim was at a level angle, the forefoot always being in contact with the water and the area distributed in such a way that as the speed increased the whole of the hull rose from the water, the alteration of trim being only 3 deg. to 3½ deg. This constancy of trim ensured that side or keel area was maintained along the whole length of the hull so that in broken water the forefoot was always dividing the oncoming sea or hill of water, without the slapping or hard riding effect. This is in direct contrast to the hull designed to ride with its forefoot out of the water, and together with other features of design and a complete balance of side areas, made possible the production of a directionally stable hull. It could be driven, "hands off" the steering wheel, all through its speed range, and with a closed throttle showed no tendency to dive, alter trim, or to yaw one way or the other.

The initial stage of development thus led to a correct distribution of plane area to maintain equal pressures along its running length and to lift the fore and aft length of the boat bodily. When a correct distribution of lateral resistance is maintained at all speeds it is possible to use rudders of nominal size. This leads, not only to a great diminution of resistance, but renders possible the use of unbalanced rudders with all their consequent advantages, and which further contributes to directional stability at

all speeds, even in a falling sea. Incidentally, there is no pay-off action from the propellers.

To achieve this result I had, of course, also to make a series of experiments with propellers, shafts, and brackets, and it is of interest to note the remarkably high speed of revolution which gave the best results. For example, with "Miss Britain III" at 100 knots, the speed of revolution of the propeller was considerably over 7000 r.p.m., but the slip was only 20 per cent. and the efficiency remarkably high.

It was not until 1930, when I built a twin-engined 200 H.P. boat designed for work with the flying boats of the Royal Air Force, which proved beyond all doubt to be superior to the old round bilge hull, that our efforts were rewarded with any hope of being able to produce something of commercial or selling value. It was obvious that for such success we could not depend on a foreign-built engine.

We tried to obtain a British-built engine and failed, and with no other alternative we decided to produce one ourselves. We discovered a British car engine of 4½ litres capacity which produced a good 100 H.P. From the standard parts we used the cylinder block, connecting-rods, valve gear, and top half of the crank case; we modified the existing crankshaft and took the drive from the end opposite the fly-wheel, attached a more or less standard form of reverse gear, similar to the American type, redesigned the piston and the whole of the oil feeding system and lubrication generally, altered the cylinder head and arranged for a different system of circulating water and pumps. We produced six engines initially; one was continuously run on the test bench and two were installed in boats for actual running experience; the remaining three were unassembled for modification of parts.

The engines in the boats were driven ceaselessly, and with the experience so gained the piston design and clearances were rearranged and small-end trouble was overcome. These trial engines were actually run for a period of 700 hours without overhaul, but at 600 hours a reduction of efficiency commenced, caused generally by the deposition of carbon. We eventually recommended that the period between overhauls should be 500 hours, but they were and are often run for 1000 hours with a falling off of power of only 10 per cent. The three remaining engines, modified as the result of the trials, were assembled, but we again experienced piston trouble. The cylinder block was then opened and examined and a fault in the casting discovered, a water jacket space which should have been there being entirely missing!

This brief description will serve to give you some idea of the building of our first marine engine. The engine was a little over ¾ lb. per H.P. lighter than the American engine, had a lower centre of gravity, and a much better petrol consumption. It also had overhead valve gear, with possibly a better carburation system, and was rather lighter in its reciprocating parts.

The question of cost then arose and in order to effect a reduction commensurate with the American price, it was necessary to jig and tool for one hundred engines, though there was then no market for them. Thus we produced a cheap British marine engine and joined the Americans in proving that it was quite unnecessary to incorporate masses of cast iron in the design of a marine engine. We also proved that high engine and propeller speeds were satisfactory.

We had therefore a 37ft. 6in. boat with two 100 H.P. engines, two propellers turning the same way, an almost negligible rudder area, excellent sea-keeping qualities, a load-carrying capacity greater than its predecessors of round bilge construction, a comparable petrol consumption, in miles per gallon, with twice the speed, and no greater initial cost.

Many hundreds of the boats have now been constructed, with no instance of failure of structure, although they have been operated in all kinds of extreme sea and weather conditions.

My small boat development was then complete. A 45ft. boat of similar characteristics was designed and met with very considerable success. An outstanding feature of this boat was that with its small-diameter high-speed propeller it could tow a picket boat minesweep with every success. This completely disproved the idea that the picket boat of the old round bilge type, with its very large-diameter slow-speed propeller, was superior to our modern light hull with its small high-speed propellers in towing effect.

Boats from 16ft. in length designed as dinghies, up to 45ft. in length, to be used as picket boats and Admirals' barges, were gradually adopted by the British Navy, and were the precursors of the fast hard chine boats now in general use.

It was only natural that boats of such novelty should meet with varying fortunes, and in their earlier days various machinery failures occurred. These were no doubt aggravated by the additional responsibility placed on the coxswain, who now had to handle both the boat and its engine, until he became accustomed to the necessary routine. A number of modifications were made to the machinery, and we increased the capacity of the salt water pump, lowered the speed, and made it of a different material to prolong its life. We provided oil strainers of much larger capacity, increased the oil cooling arrangements, invented a device in connection with the reverse gear control to prevent the throttle opening without engaging the engine, duplicated the ignition and enclosed it in a water-tight casing, and in some instances reduced the maximum power to enable the engine to be run at full throttle continuously.

I should like to mention here that we used a salt water resisting alloy for crank cases and manifolds, which has given excellent service. We have also used stainless steel and high-tensile bronzes, which have reduced maintenance costs, and have adopted an automatic ignition that retards itself at slow speed and gives the necessary advance as speeds increase. We also took the precaution of fitting automatic petrol pumps and exercised great care in the fitting of petrol and oil filters. We have never experienced the usual difficulties with pipe lines, unions, petrol cocks. Exhaust pipes have also given no trouble, as, after bitter experience the importance of great attention to these details was fully appreciated.

A paper could be written on stern glands, propeller brackets, and outside propeller shaft bearings. The latter were run in rubber, with which form of bearing I had something to do in its early stages of invention. Stern glands, despite the high propeller shaft speed gave relatively little trouble. Rubber self-aligning bearings and glands were also fitted where flexure of the hull occurred, but as they were subject to maintenance were only used in special instances. The electrical gear required a great deal of modification in order to make it resistant to sea water. Everything used in these boats was brought to a new standard of lightness, strength, and durability.

There were two outstanding types of the 40ft. and 45ft. boats, an armoured target boat for the Royal Air Force, and an armoured Customs boat for China, both boats carrying heavier loads at higher speeds than any types of hull that preceded this design.

(To be continued)

Engineering Precautions (Air Raid) Committee

No. I

THE formation and constitution of the Institution of Civil Engineers Committee on Engineering (Air Raid) Precautions was announced in October, 1938. The main problems before the Committee are to investigate the effects of high-explosive and incendiary bombs and to determine the best means of avoiding or reducing the damage which they may cause to engineering works and structures.

The study of the effects of high-explosive bombs is conveniently pursued under the following headings:

(*a*) Distant effects: Blast, Splinters;
(*b*) Local effects: Impact, Penetration, Disruption from explosion, Concussion;

and of incendiary bombs under penetration and incendiary effect.

The problem of protection can be considered in three stages:—

(1) Protection of structures against the distant effects of heavy bombs and against the combined effects of lighter bombs.

(2) Protection of public services other than structures.

(3) Protection against heavy bombardment.

The investigations of the Committee are at present concerned with fundamental problems, such as that of determining the characteristics of resistance to impact, penetration, and disruption for various materials and combinations of materials, and that of analysing the nature of blast pressure and the means of resisting it.

Much information is already available on the subject of impact, penetration and disruption, but research work is still required and is being undertaken.

On the problem of blast considerable progress has already been made, and, although the Committee's investigations have not yet been completed, it has been found possible to issue the following introductory memorandum:—

E.P.A.R. MEMORANDUM, NO. 1: BLAST

Introduction.—Blast is a shock transmitted through the air when an explosion occurs. If any considerable quantity of explosive material is involved, widespread damage may be caused by blast. That windows are shattered, even at a distance, is common knowledge and to some extent common experience; heavier structural units, such as doors, panels, and roofing materials, may be damaged at closer range; and in the immediate vicinity of the explosion the more substantial items of building construction, such as walls and floors, may be affected.

Blast is a direct consequence of the sudden transformation of the explosive material into gas at high temperature and pressure. Explosives are termed high or low according to the way in which the transformation takes place. A high explosive is one in which the transformation is almost instantaneous, and is termed detonation. The speed with which the transformation occurs is called the velocity of detonation. The magnitudes of the quantities involved in an explosion may be illustrated by considering the detonation of a cubic foot of explosive material. The amount of gas generated may be represented roughly as a volume of a 1000 cubic feet at normal temperature and pressure. The temperature of the explosion is of the order of 3000 deg. to 4000 deg. Cent., so that the potential volume of the products of explosion is some 15,000 times larger than that in which the original explosive material is contained. The static pressure of the confined gases must therefore be in the region of 100 tons per square inch. These figures are necessarily approximate, since the ordinary gas laws are not strictly applicable at these high temperatures and pressures, but they give a useful picture of the quantities involved. Considerably higher effective pressures may be developed in some cases, owing to the impact energy which results from a very high velocity of detonation.

The velocity of detonation ranges from 10,000ft. to 25,000ft. per second for typical high explosive, as compared with 600ft. to 1000ft. per second for gunpowder. Although the effect of detonation velocity on the intensity of blast has not been fully ascertained, it is known to exercise a controlling influence on the local results of an explosion. Thus, for example, 1 lb. of guncotton, which has a high detonation velocity, will cut through a steel rail, but no amount of gunpowder will produce the same effect. The shattering power of high explosive is extremely localised, and its cutting power may be lost if there is not good contact between the explosive and the objective material before detonation. The quality and intensity of the blast must also depend on the detonation velocity, but probably not to the same extent as in the case of the actual contact effects.

At the focus of the explosion disturbances may be propagated with the velocity of detonation, but as the distance increases the velocity of the blast rapidly approximates to that of a sound wave in air. There are therefore two conditions to be considered—the explosive pressure exerted at very short range by the expanding gases moving violently outwards, and the blast pressure propagated as a non-translational air wave, which may transmit the effects of the explosion to considerable distances. The range within which the direct effect of the explosion is limited, and at which the blast wave alone becomes operative, depends on the quantity of explosive detonated. In practice, it may be expressed in terms of the radius of the crater formed, say, in soft earth, when the explosive is detonated on or just below the surface of the ground. Within a range of, it may be, two or three times the characteristic crater radius of an exploding bomb or shell, the local effects of the explosion predominate, while outside such a radius it is only the distant effect transmitted by the blast wave which has to be considered. In other words, there is a zone of expansion limited within a comparatively small radius, and an outer zone in which the blast wave alone is operative. If a bomb makes a direct hit on a building or structure, the local effect may be amplified by the confinement of the expanding gases, and the destruction caused is not strictly attributable to blast.

The problem of blast in connection with a bomb explosion is therefore limited to ascertaining the effects which occur outside the zone of expansion.

In the study of this problem the full weight of organised experimental and analytical investigation has hardly had time to make itself felt, since it is only during the last year or two that the subject has become one of wide importance, apart from the empirical determination of such factors as, for example, the distance from habitable buildings at which a given quantity of explosives may safely be stored. The present sources of information are for the most part contained in the records of accidental explosions and observations of the effects of bombs dropped in wartime.

Valuable conclusions can be derived from both these sources. In the case of accidental detonations of high explosive materials, the quantities concerned are generally known with more certainty than the weight and character of a bomb dropped by enemy aircraft, and the damage is generally due to blast rather than to splinters. On the other hand, accidental explosions of the type in question usually occur in places remote from ordinary residential and commercial buildings, while numerous records are available of the damage caused by actual bombs to buildings of different types, and in such cases it is often possible to separate the effects of splinters and blast.

A picture of blast effect may be found in the record

of an accidental explosion which occurred at Perranporth, Cornwall, in January, 1902.

Three men were conveying a wagon on a light tramway from a mixing shed to a filling station; the wagon was loaded with three wooden tubs, each containing 177 lb. of blasting gelatine, with a total weight of 531 lb. The explosion, which occurred as an indirect consequence of the derailment of the wagon, was heard and felt 10 miles from the factory. The remains of the three men round the wagon were picked up at distances of 250, 250, and 150 yards respectively, in three different directions, and a piece of tramrail was found 350 yards away. The dimensions of the crater were 20ft. by 15ft. by 3ft. deep. A carter standing behind his horse, only 40ft. away, was not killed, although the horse fell dead on the spot; the man was slightly wounded in the head and his thigh was bruised, but he suffered no injury from the blast, although his hat was torn to pieces and blown to a considerable distance. Another man, standing in the porch of the "gelatine" house at a distance of 63ft., also escaped serious injury. Some structural damage was caused, and it is recorded that a door was blown off its hinges at a distance of 150 yards.

Blasting gelatine, such as that concerned in this explosion, is more powerful than the high explosive materials suitable for bomb fillings, so that it would seem to be necessary to use at least a 1000 lb. bomb with a very light case to produce a comparable effect. The effect of the thickness of the bomb casing on the intensity of blast is referred to in a subsequent paragraph, but it may be assumed for the purpose of this comparison that the blast effect of a very rapidly detonating high explosive is not diminished when the explosive is practically unconfined. The effects of the explosion just described can therefore be regarded as comparable with the blast of a light-case 1000 lb. bomb, or even of a 2000 lb. bomb with a heavier case, although the total effect of the bomb would be much greater, taking splinters into account.

The two characteristic features of an explosion are clearly distinguishable in the account of the Perranporth incident. The three men who were in the immediate vicinity of the explosion suffered the full force of the expanding gases, while the two men who escaped serious injury were outside the range of the local effects and were exposed only to blast. It is of interest to note that although the blast was sufficiently powerful to cause structural damage at a distance of 150 yards, the two men who were in such relatively close proximity to the explosion were virtually uninjured and they must therefore have been outside the zone of expansion.

Reference has already been made to the varying degrees of structural damage caused by blast, and for the purpose of ordered assessment it is convenient to adopt an arbitrary classification of degrees of destruction, such as those which correspond to the destruction of (1) windows, (2) doors and roofs, (3) light brick walls, (4) heavy brick walls. It is probably unnecessary to extend the classification, as damage to heavier structural units is generally attributable to a direct hit rather than to blast. Examples of the effect of blast on actual buildings are to be found in records of air attack on London during 1917 and 1918.*

One of the worst cases in which damage was caused by blast was that of a bomb dropped on a house in Warrington Crescent, near Paddington. "Five five-storied houses on one side of the Crescent were entirely demolished, and a very large number so badly shattered by the force of the explosion and concussion that they will have to be, in many instances, pulled down, having been rendered dangerous, in the opinion of the District Surveyor. Houses on the opposite side of the street to which the explosion occurred were unroofed, and in all these houses every bit of plaster was brought down from the ceilings and from the partition walls; very few panes of glass and sound windows were left intact within a large radius . . . the fronts of the houses on the opposite side of the road were broken and scarred, and large pieces knocked out from missiles having been hurled against them." Here the effect of the expansion was considerable, but the effect of blast was limited to damage in the first and second classes.

In another case a bomb dropped in the north-west corner of the courtyard of the Ironmongers' Hall, Fenchurch Street. The Hall is a massive brick building, about 45ft. high, built round four sides of an open court. The explosive content of the bomb was estimated by H.M. Chief Inspector of Explosives as being about 100 lb.

"The premises suffered the full effect of the explosion, owing perhaps to the fact that it took place in a comparatively confined courtyard. The confinement of this court was intensified by the fact that the external walls of the premises on the east and west sides have no openings. Some of the pavement stones, which are 2½in. thick, were hurled on to the main roof, and substantial fragments were also hurled over the building and passed over Fenchurch Street and the London Tavern, on the opposite side of the road, and were found in the churchyard of All Hallows', Steyning, at the back of the Hall of the Clothworkers' Company in Mincing Lane. The brick walls which surround the courtyard were scored and deeply pitted by missiles even at the ground level. Every pane of glass facing the four sides of the courtyard was smashed; the window frames, sashes, and sash bars were in almost all cases thrown outwards, *i.e.*, away from the centre of the explosion. The slates on the roof were for the most part stripped or loosened. The lead and iron pipes were literally riddled by missiles and cast iron columns supporting a gallery leading from the main staircase to the drawing-room at first-floor level were scored and deeply dented. . . . The great vestibule which is approached from Fenchurch Street, with its columns and plaster groining, was pitted in all directions by the force of the missiles, and the glazed wooden framing and doors between the vestibule and courtyard were entirely blown in. A significant feature of the force of the explosion is shown by the fact that the columns in the vestibule, though badly pitted by missiles, have remained practically vertical, but the caps and abaci, together with the whole of the groining, have been displaced, so that the centres of the caps in some cases are as much as 2in. out of the centre line of the columns. The surrounding brick walls of an oval stone staircase, which goes from the basement to the top of the building on the east side of the vestibule, were cracked from top to bottom. The court room on the east side of the courtyard has six sash windows. These windows, which all look into the courtyard, were entirely wrecked, and in more than one case the sash bars were shot across the room and pierced the pictures on the opposite wall like arrows. The plaster was stripped off portions of the walls and ceilings, and missiles riddled the plaster in other places. The main staircase which is approached from the vestibule comparatively escaped damage, though the walls were forced outwards and the plaster of the ceilings had fallen. The drawing-room over the court room which had five windows looking out into the courtyard was terribly wrecked, the glass chandeliers being severely damaged, and the fine mirrors hopelessly smashed. The chairs which stood adjacent to the windows were broken. The constructional timbers of the ceiling were broken and strained, and portions of the highly decorated and enriched ceiling were in imminent risk of falling.

"The small drawing-room over the general offices on the north side of the courtyard did not escape the general effects of the explosion; the ceiling had fallen, but it was curious to note that a glazed picture on the wall opposite the window was not even cracked, yet the whole of the plaster around the picture and at the back of it for an area of some 50ft. was stripped off the walls.

"The strong rooms on the ground floor and the wine cellars in the basement appear to have escaped damage, and the façade to Fenchurch Street shows little sign of the destruction and wreckage within the building. One of the pair of entrance doors in Fenchurch Street, which was bolted at the time of the raid, was forced open apparently by the suction created after the explosion. The doors open inwards—that is to say, towards the side where the bomb dropped—and the suction after the explosion was sufficiently great to make the iron bolt tear and score its way through the York stone step."

In this very full account of the destruction caused by a bomb which made practically a direct hit, the effect of blast is seen to be limited to damage in the first, second, and third classes. Reference is made to the cracking and displacement of walls, but the walls which were damaged were not demolished, and although ceiling timbers were broken and strained, they were not so damaged as to cause the collapse of the ceiling. No contemporary estimate is recorded of the total weight of the bomb, but from the weight of explosive assumed and the very formidable degree and weight of fragmentation, the effect may be considered as comparable with that of a 500 lb. bomb with a charge weight ratio of about 25 per cent.

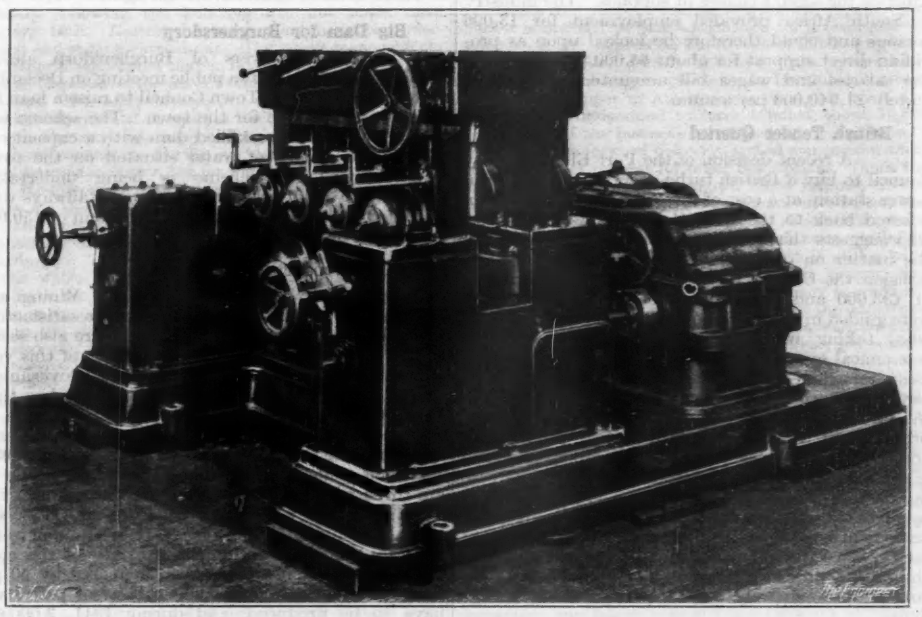
The effect of blast in the instances referred to may fairly be described as superficial, and it appears that much larger quantities of explosive are required to cause structural demolition outside the immediate locality of the explosion. A case is on record in which a whole row of dwelling-houses was levelled to the ground by the explosion of a gasholder on the opposite side of the street. This explosion occurred at Neunkirchen, Germany, in February, 1933. The houses, which were completely demolished over a frontage of 100 yards or so, were of the two-storey cottage type, but more substantial works and office buildings on the same side of the street as that on which the explosion occurred were not seriously affected. The actual weight of the explosive gases concerned in this case is not available, but it would probably be as much as 50 or 100 tons. A legitimate deduction from the cases referred to seems to be that the effectiveness of blast depends on the weight of the explosive materials detonated rather than on the velocity of detonation which is considerably lower for explosive gas mixtures than for high explosives.

(To be continued)

* Red Book, 240, "Air Raid Damage in London." The British Fire Prevention Committee, London, 1923.

Shape and Section Straightening Machine

THE accompanying engraving shows a recent design of roller type shape and section straightening machine suitable for dealing with angles up to 3in. by 3in. by ⅜in., and other sections of equal modulus. The



SHAPE AND SECTION STRAIGHTENING MACHINE

machine is manufactured by Joshua Bigwood and Son, Ltd., Wolverhampton.

It is of the eight-roll type and, in addition, is fitted with vertical rolls on the ingoing and outgoing sides, the rolls being driven through forged steel machine-cut gears. The top rolls are provided with vertical and horizontal adjustment, and are keyed on to the ends of the shafts, which rotate in heavy roller bearings in the top chocks. Vertical and horizontal adjustment is made by means of hand wheels which are placed at the front of the machine, whilst heavy thrust bearings are fitted to take the end thrust. The driving gears are totally enclosed and the roll bearings are provided with seals to retain the oil and prevent the entry of scale and dirt. One of each pair of vertical rolls is driven, the drive being taken from the main gear-box of the machine. An automatic system of lubrication is fitted to all the bearings. The machine is driven by a 25 H.P. motor with an approximate speed of 960 r.p.m. Straightening is effected at a rate of about 120ft. per minute. The machine is equipped throughout with Timken roller bearings.

A NEW DIRECTIONAL MICROPHONE.—A new microphone that picks up equally all sounds reaching it from the front, but which loses its sensitivity as the source of sound moves to a position behind it, has been developed by the Western Electric Company. If a person talking comes closer to the microphone to compensate for this loss in sensitivity, as he walks around from front to back, his path must be a heart-shaped curve or cardioid. Because of this characteristic, the device is known as a "cardioid directional" microphone.

South African Engineering Notes

(By our South African Correspondent.)

CAPE TOWN, December 20th, 1938.

Electricity Progress in South Africa

THE annual convention of the Association of Municipal Electricity Undertakings, South Africa and Rhodesia was opened at Cape Town by the Mayor, Mr. W. C. Foster, on December 5th. The Mayor, in his speech, stated that more than half of the existing electricity undertakings had been established during the last sixteen years. During that time the amount of electricity used had increased fivefold from the figure of 1,000,000,000 units in 1922. In spite of the disadvantages of being far away from the inland markets for industrial products, and 1000 miles from the coalfield, Cape Town had, by the adoption of a progressive spirit of development, increased its annual sales of electricity from 21,000,000 units in 1922 to 213,000,000 units in 1938. Mr. J. H. Gyles, the retiring President, said that the industrial census returns for South Africa revealed that of the 356 electricity undertakings, 159 owned by private companies sold seven times as much energy as the 197 owned by local authorities. Sixty per cent. of the demands was met by the stations of the Electricity Supply Commission and the Victoria Falls Power Company. Mr. Eastman, the new President of the Association, quoted figures to show that when the consumption of electric energy was considered per head of population, South Africa took a leading place among other countries, including Great Britain and the United States. The average price received by the undertakings for the sale of electric energy in South Africa was approximately 0·6d. per unit, or 0·96d. per unit for energy sold by municipal concerns only. That was also lower than the average price of 1·125d. for Great Britain and 1·15d. in America for similar classes of supplies. The industry in South Africa provided employment for 13,096 persons and could therefore be looked upon as providing direct support for about 65,000 persons, while the salaries and wages bill amounted to approximately £1,940,000 per annum.

British Tender Queried

A recent decision of the Port Elizabeth City Council to buy a British turbo-generator for the local power station, at a cost of just over £44,000, has been referred back to the Council by the Administrator, who suggests that further consideration be given to the matter on questions of price. In making their decision the Council turned down a German tender of £33,000 and a Czech tender of £30,000. They were guided in this decision by the electrical engineer, who, taking into consideration the question of economical operation over a period, advised that the British machine would be no more expensive than the foreign offers. The Council was also influenced by the fact that there is a considerable quantity of the products of the British firm whose tender was accepted in the power station and a supply of spares is carried. The Council's second choice is likely to fall on another British machine at a lower figure. It was pointed out that the cost of the operations of the power station at Port Elizabeth was a highly important factor, since the municipality pays £30,000 a year to the railways for coal freight. The actual cost of the coal is approximately only a quarter of the railage figure.

The Council has placed a contract in Great Britain for 77 miles of large-diameter steel pipes to the value of £500,000. As this order was secured on a strictly competitive basis against offers from German interests, involving barter transactions, there does not appear to be any excuse for interfering with the decision of the Council.

Graving Dock for Cape Town

Dredging work on Cape Town's new graving dock started on December 10th. This is the most important phase of the survey being undertaken by Mr. H. Noren, of Durban, on behalf of the Railways and Harbours Administration. The dredger "Springbok" and a rock breaker will be the only craft required for the work. Beacons erected along the beach at Woodstock will guide those on board the "Springbok" to the correct position in the bay. Taking their sights from these beacons, they will manoeuvre the "Springbok" to the mouth of the intended dock and start dredging there. The dredging will take some time, as weather will delay the work considerably. After a section has been dredged a rock breaker will be used. It will sink holes according to diagram in the prepared area. From these holes samples of the rock will be taken to determine how far it will be necessary to go before the hard foundation rock is reached. If it is found that the rocky bed is unsuitable for the erection of the dock at the southern seawards corner of the new mole, its position will be altered. It can only be brought nearer to the mainland, but must be in a straight line with the new mole being constructed now by the Dutch contractors. Shipping circles in Cape Town are especially interested in this section of the new harbour construction work. If the dock is built according to the present design it will be one of the three largest in the world. Although no plans have yet been submitted, it seems that the authorities are in favour of the dock being about 1150ft. long and about 130ft. broad.

Progress on New Harbour

A fifth of the new 6700ft. mole, part of the £6,000,000 harbour construction scheme, has risen from the sea bed. While this arm of the new basin is stretching southwards, the existing random block mole is slowly being demolished. Its 32,000 cement blocks will take almost two years to remove. The Dutch firm of contractors, which will receive £1,125,262 for its share of the work, will build 4000ft. of the mole. To start the erection of the mole wooden piles were driven. On these were laid rails for the pile drivers, which are moving slowly towards Woodstock to meet the Danish contractors' 4000ft. nearer Woodstock in the middle of the bay. As the pile drivers move towards Woodstock they hammer in behind them sheet steel piling. Eight thousand sheets will be used to form the walls of the mole. This sheet piling now stretches for 1350ft. and is gradually being filled in by a hopper capable of holding 900 cubic yards of sand. As the new section of this work is open to the sea the water runs away from this end and the sand settles between the two walls of steel piling, which is water-tight. The Dutch contractors' dredgers are busy day and night deepening the area, which will eventually become part of the new basin. From there the sand is filtered into barges, of which there are altogether eight. Four hold 650 cubic yards of sand and the others 190 yards. They in turn are towed by tugs to where an island is already appearing near the Marine Drive. From the barges the contents are pumped over the island and into the sea around it. This island forms the southern extremity of the area to be reclaimed. It has now almost attained its maximum distance. From this extremity, which will shortly be reached, land will be reclaimed in a straight line towards the old promenade pier. The dredgers are working day and night. Two shifts are used and tugs as well as other craft requiring fuel and water are bunkered from lighters in the bay.

Big Dam for Burghersdorp

The ratepayers of Burghersdorp almost unanimously decided at a public meeting on December 11th to authorise the Town Council to raise a loan for a new water scheme for the town. The scheme will take the form of a rockfilled dam with a capacity of 277,000,000 gallons of water situated on the town commonage. The scheme is being undertaken primarily to supply the South African Railways with water. The railways will take a minimum of 150,000 gallons per day.

Union Production of Torbanite

The South African Torbanite Mining and Refining Company was able to maintain a satisfactory rate of earnings for last year. The future also seems to be very promising. In the early part of this year a new agreement was made with the Government by which the company must produce not less than 1,000,000 gallons of petrol from torbanite crude oil during 1938, and no difficulty is being experienced in complying with this requirement. For 1939, 1,400,000 gallons of petrol from torbanite crude oil are to be produced, and in order to accomplish this a third retort was constructed during 1938 and began to operate in October. It is running satisfactorily, and as a result the capacity of the company's retorting plant has been increased by 50 per cent. During 1940, 2,000,000 gallons of petrol will have to be produced, and during 1941, 3,000,000 gallons. Additional retorting plant will be constructed during the present year to comply with these requirements. After 1941 the company is obliged to produce such quantities of petrol from torbanite crude oil as are equal to 50 per cent. of the company's total output of refined spirit. The company is entitled to import such quantities of crude oil as will enable it to produce a total of 6,000,000 gallons of motor spirit per annum. The Government grants rebates in freight rates on the railways and complete freedom from customs and *ad valorem* duties on imported crude oil.

Co-ordination of Transport

The General Manager of the South African Railways, in the course of his annual report, states: "It is a matter for serious consideration whether the time is not ripe for an organisation to be adopted whereby all forms of public transport will be co-ordinated in the best interests of the country as a whole, and the South African Railways and Harbours placed outside the vortex of the many external influences which are making it increasingly difficult to maintain discipline and efficiency, and to administer the railways on business principles, as laid down in Section 127 of the South Africa Act. In my opinion, the time for such action is overdue." In the report the following extract from the recommendations, &c., of the Departmental Accidents Committee is quoted:—"The Committee directs attention to the fact that notwithstanding the large number of mechanical safeguards and aids provided by the Administration, nearly one-third of the train accidents which occurred during a recent period of fifteen months can be ascribed directly to human fallibility. In the matter of minimising the extent of possible lapses on the part of railway servants, the same problem presents itself to all railway undertakings, for there is no known method whereby continuous 100 per cent. alertness can be ensured for the railway operating staff. The introduction of mechanical safeguards in train operating systems serves as a check on the human element, and the policy of extending the application of such devices is one which to-day is being actively pursued by the South African as well as by all modern railway concerns."

Stewarts and Lloyds' South African Company

The operations of Messrs. Stewarts and Lloyds at their Vereeniging steel tube-making works were highly successful during the past year. Sales amounting to £2,238,293 represent an increase of £209,728 on the turnover for the previous financial year, and once more constitute a record. The Vereeniging works operated to full capacity throughout the year, the tonnage of finished products despatched being substantially in excess of the total for the financial year ended June 30th, 1937. The third tube-making unit is not yet operating, its erection having been retarded owing to the delay in obtaining plant deliveries from overseas. Shipments of the balance of the necessary machinery to complete the unit are, however, now coming forward, and it is hoped that the new push bench will be in production in the course of a couple of months. The trading profit for the year, including income from investments and after debiting debenture interest, directors' fees, and depreciation, amounts to £269,567, as compared with £204,410 for the previous financial year.

Rand–Pretoria Rail Service

The £200,000 railway electrification scheme between Germiston and Elandsfontein, which has taken 2½ years to carry out, was completed at midnight on December 4th, when the electric overhead traction wire was connected up to the new cable bridges. This means that there is now a double track all the way from Johannesburg to Pretoria, and a greatly increased amount of traffic is being carried. Up till December 5th the stretch of track between Elandsfontein and Germiston had been only single. The increased amount of traffic which the new line permits allows the easy and frequent running of special trains which will be a great convenience and has already proved its value when conveying thousands of visitors from all parts of the Reef to Pretoria this month for the Voortrekker celebration.

British Tenders Barred

Much attention has been attracted to the fact that British products have been excluded in advance from tenders calling for the supply of a quantity of pure chemicals for the Onderstepoort laboratories. On the tender form, as an introduction to the list of 144 chemicals, it is stated: "All chemicals on this list must be the products of either or all of the following firms." Two of the firms named are in Berlin and the other in Darmstadt, Germany. The tender was advertised in the Government *Gazette*, and representatives of British firms cannot understand why it is that they are not even to be allowed to quote prices. It is stated as a fact that British firms are able to supply a great majority of the products required. Whether they would have been more expensive or cheaper than the German manufactures is beside the point. The fact remains, say the representatives, that no firm outside three German concerns is to get the contract.

PERSONAL AND BUSINESS ANNOUNCEMENTS

JOHN NORTH (FOUNDERS AND ENGINEERS), Ltd., Clifton House, Euston Road, London, N.W.1, have been appointed by Davey, Paxman and Co. (Colchester), Ltd., as their sole selling agents for the whole of the outside output from their foundry.

MESSRS. BINNIE, DEACON AND GOURLEY, chartered civil engineers, Westminster, S.W.1, have taken into partnership Mr. Geoffrey M. Binnie, M.A. (Cantab), Assoc. M. Inst. C.E., the son of their senior partner. The name of the firm will remain unchanged.

STANELCO PRODUCTS, which has recently opened offices at 163, Great Portland Street, London, W.1, is an offshoot of Standard Telephones and Cables, Ltd. It will carry out the marketing and eventual manufacture of refrigerating and air-conditioning equipment, portable electric tools, temperature, and pressure control instruments, switchgear, &c. The general manager of Stanelco Products is Mr. A. McVie, foreign director of Standard Telephones and Cables.

CATALOGUES

KING, TAUDEVIN AND GREGSON, Ltd., Melbourne Chambers, Cambridge Street, Sheffield, 1.—Particulars of the "Fofumi" rotary hearth melting furnace.

JOHN THOMPSON WATER TUBE BOILERS, Ltd., Wolverhampton.—A brochure illustrating and describing the construction and working of the La Mont boiler.

E. P. BARRUS, Ltd., 36, Upper Thames Street, E.C.4.—Particulars of the "Armco" 6in. precision shaper and the "Black Diamond" precision tool grinder.

S. WOLF AND CO., Ltd., Hanger Lane, Ealing, W.5.—Leaflets describing the "Wolf" range of electric tools, which include tool post grinders, electric hand tools, valve grinding sets, &c.

FIRTH VICKERS STAINLESS STEELS, Ltd., Staybrite Works, Sheffield, 9.—"Manne Specification Book," indicating where "Staybrite" rust-resisting steel may be embodied in new or revised specifications.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer. A comprehensive list of the prices of materials mentioned below will be found on the next page.

The Portuguese Market

The report on the Economic and Commercial Conditions in Portugal to August, 1938, issued by the Department of Overseas Trade and published by H.M. Stationery Office, price 1s. 6d. net, does not give a very reassuring picture of British trade with that country. There was a sharp drop in Portuguese imports in the first quarter of 1938 when that country felt the effects of the depression in the United States, the depreciation of the franc, and the Brazilian default, and in September, 1938, the signs of a recovery were very slight. Germany was the principal beneficiary by the increase in imports in 1937, her exports to Portugal expanding by £640,000, of which £365,000 were attributed to the purchase of war material (rifles and ammunition.) Great Britain's principal competitors in the Portuguese market are Germany, the United States, and Belgium. The imports from Germany during the first nine months of 1938 were valued at £2,065,000, being 14·83 per cent. of the total import trade, whilst from Great Britain imports were valued at £2,301,000, or 16·52 per cent. of the total. There were increased imports of coal from Germany at the expense of Great Britain, which had hitherto enjoyed almost the whole market. The efforts of German importers to obtain a larger share of the coal trade were intensified, and appear to have met with a certain measure of success. It is not that Germany has been able to take advantage of the trading position to influence purchasing in Germany by means of block mark accounts, for the balance of trade is against Portugal. Organisation, lower prices, and more favourable terms of credit are responsible. A recent order for machinery for Germany amounting to £45,000 provided for payment of 25, 50, 15, and 10 per cent. of the price in the years 1938–1941. So far as prices are concerned, the system by which German trade is financed and subsidised affords opportunities of securing orders which are impracticable in other countries. British pig iron is greatly appreciated in the Portuguese market, and is still preferred by many foundries on account of its qualities, but it has to compete to-day with the Belgian product. It will be observed also that in the last two years the United States has entered this market. In the case of tinplates, Great Britain at one time enjoyed supremacy in the Portuguese market, but has now lost ground to Germany and the United States. The imports of Belgum consist mainly of galvanised sheets, and that country supplies almost all the Portuguese requirements. Imports of wire from Great Britain rose during the latter half of 1937 when British manufacturers were quoting prices practically equal to those of the Cartel. Competitive prices were, however, said to be lower in 1938, and imports from Great Britain declined.

British Iron and Steel Production

The Report of the British Iron and Steel Federation states that the production of pig iron in December totalled 445,800 tons, compared with 461,500 tons in the previous month. It included 95,900 tons of hematite, 255,800 tons of basic, 78,500 tons of foundry, and 9600 tons of forge iron. Production in December was, of course, influenced by the holiday conditions ruling at most of the works. The output of pig iron for 1938 amounted to 6,763,000 tons, against 8,493,100 tons in 1937. The total production of steel ingots and castings in December declined to 655,700 tons from 860,000 tons in November, making the figure for the year 10,394,000 tons, compared with 12,984,000 tons in 1937. The number of furnaces in blast at the end of December showed a net decrease of one to seventy-eight, five having been blown in and six put out of commission. The following are the units affected, of which details are not included in the Report :—The Skinningrove Iron Company, Ltd., Saltburn-by-Sea, two blown in ; Shelton Iron, Steel and Coal Company, Ltd., Stoke-on-Trent, one out and one in ; John Lysaght, Ltd., Scunthorpe, one blown in ; Barrow Hematite Steel Company, Ltd., one out ; Renishaw Iron Company, Ltd., near Sheffield, one out ; Rd. Thomas and Co., Ltd., Ebbw Vale, one blown in and one out ; Shotts Iron Company, Ltd., two out. The following table gives the monthly average production of pig iron and steel and the output for the past six months :—

	Pig iron, tons.	Steel, tons.
1913—Monthly average ...	855,000	638,600
1920 " " ...	669,500	755,600
1929 " " ...	632,400	803,000
1931 " " ...	314,400	433,500
1932 " " ...	297,800	438,500
1933 " " ...	344,700	585,300
1934 " " ...	497,400	737,500
1935 " " ...	535,300	821,600
1936 " " ...	643,500	982,100
1937 " " ...	707,800	1,082,000
1938 " " ...	563,600	866,200
July	507,800	683,200
August	443,000	658,900
September	429,800	754,700
October	469,400	854,800
November	461,500	860,000
December	445,800	655,700

The Pig Iron Market

Business in the iron and steel markets, including the pig iron section, has been on a quiet scale. This, however, is usually the case in the early days of the New Year and has not damped the confidence with which prospects for the quarter are viewed by the market. Stocks of pig iron increased during the holidays, when deliveries to the consuming works were suspended, but the accumulations were insufficient to affect the position, and are well below those existing a year ago. The amount of inquiry in circulation has been quite up to expectations, but it must be admitted that so far only a limited amount of business has been transacted. On the North-East Coast the makers have opened their books for delivery over the first half of the year, and a few sales have been recorded, but no business of any importance seems to have been done. Consumers of foundry iron have reduced their reserves in many cases to an unusually low level. The starting up of a furnace at Skinningrove on foundry iron has strengthened confidence in the outlook, since it is some months since this quality was produced regularly on the North-East Coast. Anticipations are current that the demand before the end of the month will have improved sufficiently to warrant the starting up of other furnaces on this quality, but up to the present the amount of business offering has not been such as to make this justifiable. The lower export quotation of £5 f.o.b. has not brought out any fresh business. In the Midlands the market has been in much the same condition as immediately before the holidays, with the exception that there has been a certain amount of inquiry. Buyers appear to be on the verge of entering the market in some force, and it seems likely that the hand-to-mouth purchasing which has been in evidence for the last six months will give place to more normal trading. A certain amount of buying for forward delivery has already taken place, although the tonnages involved have been comparatively small. The light castings makers are taking a conservative view of the market, since the demand for their own products is far from satisfactory. In some instances also firms in this section of the industry still have rather heavy stocks. In Scotland the market was idle last week, owing to the New Year holidays, but when these are out of the way it is expected that there will be more active buying than for some time. Conditions in the hematite market do not show much improvement, and the makers are carrying much heavier stocks than they like. It is probable that production is in excess of demand, and this with the tonnages already in the hands of the makers gives the market a top-heavy appearance. Some improvement, however, has been noticeable this year in the volume of specifications against old contracts.

Scotland and the North

A full restart of operations in the Scottish steel industry following the holidays was not made until January 10th. During the break plant had been overhauled and repairs carried out. The works managements are rather disappointed that so far there has been no very decided response on the part of consumers to the reduction in prices. It is early days yet, however, and it is pointed out that any revival in trade is likely to be delayed until towards the end of January. The lack of orders for new merchant vessels is having an unfavourable influence upon the steel industry, but for the time being there seems little likelihood of any improvement in the volume of orders for this class of ships. Expectations are current that the Government will come to the assistance of the shipbuilding industry, and that the steel works will benefit accordingly. The Scottish constructional engineers are, on the whole, fairly well employed, but in some cases they have not taken delivery of the steel contracted for in the early part of last year. It is probable, however, that in the majority of cases the careful buying which preceded the reduction in prices will be succeeded by more active conditions during the next few weeks. The boiler makers all have a considerable amount of work in hand, but it is to be feared that for the most part they have covered their requirements, and that no important business will be received from this branch until they have secured fresh orders. The steel works anticipate receiving a considerable amount of business arising from the rearmament programme, and, in particular, a strong demand for joists in connection with A.R.P. requirements. Another section of the engineering industry which is busy and likely to remain so for some time is the machine tool department. The rearmament programme has resulted in a considerable demand for this class of machinery, and it is providing a good outlet for steel. The Scottish tube trade is in a better position as regards work in hand than for some time, chiefly as the result of some important orders received in the latter part of last year for tubes for oil companies. It is also expected that the collieries will require considerable supplies of tubular steel pit props this spring. Since business was resumed in the Lancashire market trading has not been much brighter than before the holidays. There is considerable irregularity in the position of the consuming works in this district. The constructional engineers, for instance, are fairly well employed, but there are firms that have worked off contracts and are anxious to secure new orders. A fair amount of business has been placed for delivery over the first six months of the year, a good proportion of which has been for boiler and tank plates. In the Barrow district, the outlook is regarded as promising, and a certain amount of new business has been received since the holidays.

Current Business

Extensions are to be made to the Thorncliffe Iron Works, near Sheffield, of Newton, Chambers and Co., Ltd., for the production of excavators. Larger machine shops will be incorporated, and the cost is estimated as likely to run into six figures. Premises in Carlisle Street East, previously used as a school, have been acquired by Thos. Firth and John Brown, Ltd., and Firth-Vickers Stainless Steel, Ltd., for their sales promotion department. The business of the late Mr. Wm. H. Parker, steel and file merchant, of Olde Time Works, Baron Street, Sheffield, has been bought by Wm. Turner and Sons, Ltd., steel makers, of Caledonia Works, Sheffield. The road roller business of John Fowler and Co., of Leeds, and their subsidiary company in India has been bought by Marshall, Sons and Co. (Successors, Ltd.), agricultural and general engineers, of Gainsborough. The Brush Electrical Engineering Company, Ltd., Loughborough, has received an order for a 20,000-kW Brush-Ljungstrom turbo-alternator from the Halifax Corporation at an approximate cost of £70,000. The Guest Keen Baldwin type of shelter construction has been officially approved by the Home Office A.R.P. Department. Bernard Holland and Co., 17, Victoria Street, London, S.W.1, have been appointed sole selling agents for Maag, Zurich, Switzerland, gear cutters and manufacturers of all descriptions of specialised gears and gear-grinding machines. It is proposed to increase by 200 per cent. the output of the Vitreflex Company, Ltd., of Dafen Llanelly, makers of reinforced galvanised sheets with enamel finish. The company is associated with the Dafen Tin-plate and Galvanising Company, Ltd. A site adjoining the present factory has been acquired. Petters, Ltd., at an extraordinary meeting, passed a special resolution changing the name of the company to Associated British Engineering, Ltd. The Department of Overseas Trade announces that the following contracts are open for tender :—South African Railways and Harbours Administration : Supply and delivery of thirty lengths rolled steel beams to B.S.S. No. 153, Part I, 22in. by 7in. by 75 lb. by 34ft. (Johannesburg, January 26th). Bangkok, Royal State Railways of Siam : Steel superstructures of railway bridges for metre gauge railways, single line (Siam, April 13th). Melbourne, Victoria Railways Commissioners : Quantities of black steel steam tubes to specification (Melbourne, C.I., February 1st). Indian Stores Department : 2000 screw couplings, B.G. without hook shackles, shackle pin, pin collar, and rivet (New Delhi, January 25th).

Copper and Tin

The demand for electrolytic copper has been limited to comparatively small parcels, and consumers have shown a tendency to buy from hand to mouth. It is anticipated that the statistics for December will present the position in a rather unfavourable light, and this belief may have influenced consumers in the attitude they are taking. The restriction of output was not in operation long enough in December to affect the situation greatly, but it is probable that it will be reflected in the figures for the present month, and that for some months to come there will be a gradual improvement. Government buying which was such an important feature of the market at the beginning of the last quarter of the year has become almost normal, with the exception of some fairly large purchases by Russia and more moderate buying by Japan. The market is inclined to look to America for a lead, and for that reason any signs of an improvement in the American trade position are quickly followed by a sympathetic movement in the copper market. In December the consumption of copper in America was distinctly poor, and the sales are understood to have totalled about 14,000 tons. Most of the business transacted lately has been in electrolytic for forward delivery, and in comparison there has been a poor request for other descriptions. Since the holidays, speculators have shown more interest in the standard copper market, but the volume of business has not been sufficient to give a firm tone. There has been a fair amount of hedging by producers, who were probably disposing of their surplus output. There is still a wide margin between standard and electrolytic copper, and the carrying rate lately has shown a tendency to contract. It is not easy now to obtain 5s. . . . Whilst the undertone of the tin market remains firm, consumers have shown little disposition to transact much business. The rigid control exercised by the International Tin Committee and the belief that some 9000 tons of the available supplies of tin shown in the statistics are controlled by the Buffer Pool, creates the feeling that, although conditions may be artificial, the control will be sufficiently strong to enable prices to be raised. On the other hand, in spite of expectations that values may advance, consumers are buying in limited quantities and are refusing to commit themselves for important tonnages. The general impression is that the Pool will not release its tin until the price reaches the neighbourhood of £230, but, of course, this is not certain.

Lead and Spelter

The lead market has again developed an easy appearance and prices have shown a tendency to recede. This was probably the result of declarations of Empire and Mexican lead to arrive in January, which are rather heavier than were expected. It is likely that a fair proportion of this metal will be put into warehouse. The market is rather sensitive to outside influences, and the somewhat weaker tone of the American stock markets at the beginning of the week may have had something to do with the easiness which developed in London. Confidence in the future of lead has declined considerably during the past few weeks, and even the possibility that at long last the producers' restriction scheme will begin to affect supplies has not created much impression. Attention seems to be concentrated upon the poor building statistics and the rather weak demand from the Continent. The latter, it is said, is largely because some of the chief consuming countries have not the necessary foreign exchange to cover their full requirements. It is expected, however, that for a time at any rate Russia will be a good buyer, but the probability is that other European Governments will not take a tonnage equal to that bought in the last quarter of 1938. The stocks in the United States at the end of November were the smallest throughout the year, and totalled only 115,236 tons, compared with 117,476 tons on October 30th. Production of lead in November increased to 39,801 tons from 31,843 tons in the previous month. . . . No feature of interest has developed in the spelter market, and the position seems very much the same as that ruling before the Christmas holidays. The general tendency is towards weakness, and but for the fact that prices have already fallen to a low level, the appearance of the market would suggest a further recession. As it is the present quotation and the disappointing outlook must present rather serious problems to a number of the mines. Production has been affected by the low prices to the extent that there has been some decline, but it would seem that there has been an even greater fall in industrial requirements. The zinc producers in the United States have lodged a protest at Washington, claiming that widespread shut-downs have resulted from the trade agreements between Great Britain, the United States, and Canada, which, they argue, have left the American market open to Canadian imports. It is not expected, however, that the complaint will be allowed to affect the position.

Current Prices for Metals and Fuels

Makers' official home trade price, per ton, delivered buyers' stations. *Joists, Sections, Bars and Plates are subject to a rebate of 15s. to home users purchasing only from Associated British Steelmakers. † Export prices are for Empire Markets; for other Markets British quotations conform to Cartel prices.

PIG IRON.

Foundry home prices, except for Scotland, less rebate of 5/–

(*D/d Teesside Area.*)

	Home. £ s. d.	Export. £ s. d.
N.E. COAST—		
Hematite Mixed Nos.	6 0 0	—
„ No. 1	6 0 6	5 15 0
Cleveland—		
No. 1	4 19 0	5 2 6
No. 3 G.M.B.	4 17 6	5 0 0
No. 4 Foundry	4 7 6	—
Basic	4 12 6	—
MIDLANDS—		
Staffs— (*Delivered to Black Country Station.*)		
North Staffs. Foundry	5 1 0	—
„ „ Forge	4 16 0	—
Basic	4 12 6	—
Northampton—		
Foundry No. 3	4 18 6	—
Forge	4 15 6	—
Derbyshire—		
No. 3 Foundry	5 1 0	—
Forge	4 18 6	—
SCOTLAND—		
Hematite, f.o.t. furnaces	6 0 6	—
No. 1. Foundry, ditto	5 8 0	—
No. 3 Foundry, ditto	5 5 6	—
Basic, d/d	4 12 6	—
N.W. COAST— Hematite Mixed Nos.	6 0 6 d/d Glasgow 6 6 0 „ Sheffield 6 12 0 „ Birmingham	

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
LANCS. AND YORKS.—		
Crown Bars	12 5 0	—
Best Bars	12 15 0	—
MIDLANDS—		
Crown Bars	12 5 0	—
Marked Bars (Staffs)	15 15 0	—
No. 3 Quality	10 17 6	—
No. 4 Quality	11 7 6	—
SCOTLAND—		
Crown Bars	12 5 0	12 5 0
Best	12 15 0	12 15 0
N.E. COAST—		
Crown Bars	12 5 0	12 5 0
Best Bars	12 15 0	12 15 0
Double Best Bars	13 5 0	13 5 0
NORTHERN IRELAND AND FREE STATE—		
Crown Bars, f.o.q.	12 17 6	—

STEEL.

	*Home. £ s. d.	†Export. £ s. d.
LONDON AND THE SOUTH—		
Angles	10 10 6	10 0 0
Tees	11 10 6	11 0 0
Joists	10 10 6	10 0 0
Channels	10 15 6	10 5 0
Rounds, 3in. and up	11 10 6	11 0 0
„ under 3in.	11 17 6‡	11 0 0
Flats, under 5in.	11 17 6‡	11 0 0
Plates, ¼in. (basis)	10 15 6	10 2 6
„ ⅜in.	11 0 6	10 7 6
„ ½in.	11 5 6	10 12 6
„ ⅝in.	11 10 6	10 17 6
Un. ⅛in. to and incl. 6 lb. per sq. ft. (8-G.)	11 12 6	12 10 0
Boiler Plates, ¼in.	11 5 6	11 12 6
NORTH-EAST COAST—		
Angles	10 8 0	10 0 0
Tees	11 8 0	11 0 0
Joists	10 8 0	10 0 0
Channels	10 13 0	10 5 0
Rounds, 3in. and up	11 8 0	11 0 0
„ under 3in.	11 15 0‡	11 0 0
Plates, ¼in. (basis)	10 10 6	10 2 6
„ ⅜in.	10 15 6	10 7 6
„ ½in.	11 0 6	10 12 6
„ ⅝in.	11 5 6	10 17 6
Un. ⅛in. to and incl. 6 lb. per sq. ft. (8-G.)	11 12 6	12 10 0
Boiler Plates, ¼in.	11 0 6	11 12 6
MIDLANDS, AND LEEDS AND DISTRICT—		
Angles	10 8 0	10 0 0
Tees	11 8 0	11 0 0
Joists	10 8 0	10 0 0
Channels	10 13 0	10 5 0
Rounds, 3in. and up	11 8 0	11 0 0
„ under 3in.	11 16 0‡	11 0 0
Flats, 5in. and under	11 15 0‡	11 0 0
Plates, ¼in. (basis)	10 13 0	10 2 6
„ ⅜in.	10 18 0	10 7 6
„ ½in.	11 3 0	10 12 6
„ ⅝in.	11 8 0	10 17 6
Un. ⅛in. to and incl. 6 lb. per sq. ft. (8-G.)	11 12 6	12 10 0
Boiler Plates, ¼in.	11 3 0	11 12 6

STEEL (*continued*).

	*Home. £ s. d.	†Export. £ s. d.
GLASGOW AND DISTRICT—		
Angles	10 8 0	10 0 0
Tees	11 8 0	11 0 0
Joists	10 8 0	10 0 0
Channels	10 13 0	10 5 0
Rounds, 3in. and up	11 8 0	11 0 0
„ under 3in.	11 15 0‡	11 0 0
Flats, 5in. and under	11 15 0‡	11 0 0
Plates, ¼in. (basis)	10 10 6	10 2 6
„ ⅜in.	10 15 6	10 7 6
„ ½in.	11 0 6	10 12 6
„ ⅝in.	11 5 6	10 17 6
Un. ⅛in. to and incl. 6 lb. per sq. ft. (8-G.)	11 12 6	12 10 0
Boiler Plates, ¼in.	11 0 6	11 12 6
SOUTH WALES AREA—		
Angles	10 8 0	10 0 0
Tees	11 8 0	11 0 0
Joists	10 8 0	10 0 0
Channels	10 13 0	10 5 0
Rounds, 3in. and up	11 8 0	11 0 0
„ under 3in.	11 15 0‡	11 0 0
Flats, 5in. and under	11 15 0‡	11 0 0
Plates, ¼in. (basis)	10 13 0	10 2 6
„ ⅜in.	10 18 0	10 7 6
„ ½in.	11 3 0	10 12 6
„ ⅝in.	11 8 0	10 17 6
Un. ⅛in. to and incl. 6 lb. per sq. ft. (8-G.)	11 12 6	12 10 0

IRELAND—F.O.Q.—	BELFAST. £ s. d.	REST OF IRELAND. £ s. d.
Angles	10 13 0	10 15 6
Tees	11 13 0	11 15 6
Joists	10 13 0	10 15 6
Channels	10 18 0	11 0 6
Rounds, 3in. and up	11 13 0	11 15 6
„ under 3in.	12 0 0‡	12 2 6
Plates, ¼in. (basis)	10 15 6	10 18 0
„ ⅜in.	11 0 6	11 3 0
„ ½in.	10 5 6	11 8 0
„ ⅝in.	11 12 6	12 10 0
Un. ⅛in. to ¼in. incl.	11 12 6	11 12 6

‡ *Rounds and Flats tested quality; untested, 6s. less.*

OTHER STEEL MATERIALS

	Home. £ s. d.	Export, f.o.b. £ s. d.
Sheets—		
11-G. and 12-G., d/d	13 15 0	11-G. to 14-G. 12 10 0
13-G., d/d	14 2 6	
14-G. to 20 G., d/d	14 10 0	15-G. to 20-G. 12 15 0
21-G. to 24-G., d/d	14 15 0	21-G. to 24-G. 13 0 0
25-G. and 26-G., d/d	15 10 0	25 and 26-G. 13 15 0

South Africa, Rhodesia, Nyasaland, £14; Canada, £14 12s. 6d., f.o.b. basis. Irish Free State, £14 15s., f.o.q., 4-ton lots.

The above home trade sheet prices are for 4-ton lots and over; 2-ton to 4-ton lots, 7s. 6d. per ton extra; and under 2-ton lots to 10-cwt., £2 per ton extra.

Galvanised Corrugated Sheets, basis 24-G.—

Home.	£ s. d.
4-ton lots and up	17 5 0
2-ton to 4-ton lots	17 12 6
Under 2 tons	18 17 6

Export: India, £15 15s. c.i.f.; Irish Free State, £17 5s., f.o.q.; General, £15 15s., f.o.b., 24-G. basis.

TIN-PLATES— 20 by 14 basis, f.o.b., Bristol Channel Ports, 20s. 3d.

Tin-plate Bars, d/d Welsh Works, £7 5s.

BILLETS—100-ton lots and over, 35 to 100 tons, 5s. extra; less than 35 tons, 10s. extra.

	£ s. d.
Soft (up to 0·25% C.), untested	7 7 6
„ „ tested	7 12 6
Basic (0·33% to 0·41% C.)	7 17 6
„ Medium (0·42 to 0·60% C.)	8 10 0
„ Hard (0·61% to 0·85% C.)	9 0 0
„ „ (0·88% to 0·99% C.)	9 10 0
„ „ (over 0·99% C.)	10 0 0
Rails, Heavy, 500-ton lots, f.o.t.	9 10 0
„ Light, f.o.t.	8 10 0

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	4/9½ per lb. (nominal)	
Ferro-Tungsten	4/8 per lb. (nominal)	
Ferro-Chrome, 4 p.c. to 6 p.c. carbon	£23 15 0	7/6
„ 6 p.c. to 8 p.c.	£23 10 0	7/6
„ 8 p.c. to 10 p.c.	£23 10 0	7/6
„ Max. 2 p.c. carbon	£36 0 0	11/–
„ „ 1 p.c. carbon	£38 5 0	11/–
„ „ 0·5 p.c. carbon	£41 0 0	12/–
„ „ carbon-free	10d. per lb.	
Metallic Chromium	2/5 per lb.	
Ferro Manganese (loose), 76 p.c.	£16 15 0 home	
„ Silicon, 45 p.c. to 50 p.c.	£12 10 0 scale 5/– p.u	
„ „ 75 p.c.	£17 0 0 scale 6/– p.u	
„ Vanadium	14/– per lb.	
„ Molybdenum	4/9 per lb.; 5/– forward	
„ Titanium (carbon-free)	9d. per lb.	
Nickel (per ton)	£185 to £190 per ton	
Cobalt	8/6 to 8/9 per lb.	

NON-FERROUS METALS.

(*Official Prices, January 11th.*)

COPPER—	
Cash	£43 13 9 to £43 15 0
Three Months	£43 18 9 to £44 0 0
Electrolytic	£48 10 0 to £49 10 0
Best Selected Ingots, d/d Birmingham	£49 5 0
Sheets, Hot Rolled	£80 0 0

	Home.	Export.
Tubes, Solid Drawn (basis)	12¾d.	12¾d.
„ Brazed (basis)	12¾d.	12¾d.

BRASS—	
Ingots, 70/30, d/d Birmingham	£38 0 0

	Home.	Export.
Tubes, Solid Drawn, 2/1 Alloy	11¼d.	11¼d.
„ Brazed	13¼d.	13¼d.

TIN—	
Cash	£217 0 0 to £217 5 0
Three Months	£218 0 0 to £218 5 0
SPELTER—	
Cash	£13 19 9 to £13 15 0
Three Months	£13 17 6 to £13 18 9
LEAD—	
Cash	£14 15 0 to £14 17 6
Three Months	£14 18 9 to £15 0 0
Aluminium Ingots (British)	£94 (net)

FUELS.

SCOTLAND

	Export.
LANARKSHIRE— (f.o.b. Grangemouth)—	
Navigation Unscreened	18/6
Hamilton Ell	18/6
Splints	19/– to 19/6
AYRSHIRE— (f.o.b. Ports)—Steam	16/6 to 17/–
FIFESHIRE— (f.o.b. Methil or Burntisland)—	
Prime Steam	17/6 to 18/–
Unscreened Navigation	18/– to 18/6
LOTHIANS— (f.o.b. Leith)—Hartley Prime	17/6
Secondary Steam	16/9

ENGLAND

SOUTH YORKSHIRE, HULL—	
B.S.Y. Hards	20/6 to 21/–
Steam Screened	17/6 to 18/–
NORTHUMBERLAND, NEWCASTLE—	
Blyth Best	18/6
„ Second	17/–
„ Best Small	17/–
Unscreened	17/– to 18/–
DURHAM—	
Best Gas	19/4½
Foundry Coke	27/– to 28/–

SOUTH WALES

CARDIFF— Steam Coals:	
Best Admiralty Large	24/–
Best Seconds	23/6 to 24/–
Best Dry Large	23/– to 23/6
Ordinaries	23/–
Bunker Smalls	16/– to 17/6
Cargo Smalls	15/6 to 16/–
Dry Nuts	27/6 to 28/–
Foundry Coke	31/– to 42/6
Furnace Coke	29/–
Patent Fuel	25/6
SWANSEA— Anthracite Coals:	
Best Large	38/– to 41/–
Machine-made Cobbles	41/– to 45/6
Nuts	40/– to 45/–
Beans	33/– to 38/6
Peas	26/– to 30/–
Rubbly Culm	15/– to 16/–
Steam Coals:	
Large Ordinary	22/6 to 24/6

FUEL OIL.

Inland consumption: contracts in bulk.

Exclusive of Government tax of 1d. per gallon: and 9d. per gallon on oil for road vehicles.

Ex Ocean Installation.	Per Gallon.
Furnace Oil (0·950 gravity)	3¾d.
Diesel Oil	4¼d.

French Engineering Notes

(From our own Correspondent in Paris.)

Hydrogenation Works

PLANS for the installation of hydrogenation works producing petrol for aero-engines are to be put in hand at once. The systems to be employed are those that have been developed at the Béthune and Liévin collieries where experimental plants have been in operation for the past three years, both of them based on the Bergius principle and differing from existing installations by modifications of the process introduced by Monsieur F. Vallette, chief engineer of the Béthune Colliery Company, and by Monsieur E. Audibert, whose method is used at Liévin for the hydrogenation of different materials, including lignite and waste from petroleum distillation. These experiments are declared to have given satisfactory results. The work has been done privately with financial aid from the State, and the State will now control the organisation of new hydrogenation works to be erected and carried on by companies with private and State capital and with loans guaranteed by the State. The chief concern engaged in the execution of the programme is the Compagnie Française de Raffinage, in which the State is a large shareholder. It will erect two hydrogenation works, one in proximity to the refinery at the petroleum port of Douges on the Seine, a few miles from Havre, where 70,000 tons of petrol will be produced annually from distillation residuum, and another at Martigues, near Marseilles, where waste from the neighbouring refinery and also lignite from the Bouches-du-Rhône will be treated. In view of the success claimed to have been obtained in Germany with the hydrogenation of lignite it is confidently believed that the results of the experimental working at Liévin give promise of a satisfactory utilisation of the country's resources in lignite, which are fairly extensive. The third works will be established at Decazeville, to exploit the system of coal hydrogenation that has been developed at the Béthune colliery. Negotiations are in progress with the International Hydrogenation Patents Company for installing a plant at Pauillac, on the Gironde. According to an official announcement the company requires no capital from the State, which is asked to purchase annually 100,000 tons of petrol for a definite period. The only other hydrogenation works is one owned by the private company, Courrières-Kuhlmann, which employs the Fischer system. Speaking of Douges, where one of the plants will be installed, reference may be made to a Government announcement some time ago that a pipe line would be laid from that petroleum port to Montargis; but when referring last week to the construction of hydrogenation works, the Minister of Public Works declared that he was opposed to the pipe line for the reason that it appeared inopportune at a time when it was desirable to avoid competition with the railways. Moreover, he did not think that the pipe line covered a sufficiently wide area of distribution.

Colonial Development

At a time when the colonies attract so much interest among nations to which they do not belong, it is felt that the French themselves should be awakened to the importance of the work being undertaken to develop these overseas possessions and make them an integral part of the country's economic system. The work is being carried out everywhere under great difficulties. To say nothing of road construction to link up West Africa with the north, there is much of interest in the creation of ports which, in the absence of natural sites for harbours on the West African coast, has often to be done at heavy cost. The construction of the port of Dakar necessitated the building of 4500 m. of wharves and sea walls for the accommodation of ships drawing 10 m. of water, and work is now in hand on an outer basin where it will be possible to moor safely three warships of 35,000 tons. Work is also in progress at the port of Conakry, in Guinea, and at Abidjan, on the Ivory Coast, where the coast line is to be cut through into a deep lagoon and protected outside by sea walls. In Equatorial Africa one of the most noteworthy achievements is the creation of the port of Pointe Noire, which is connected with Brazzaville by rail. The low belt of coast, with the tropical forest in the background, shelves for nearly a mile to a point where the water is deep enough for ships to berth alongside the sea wall and wharf. A town has been built and the construction of quays is well advanced, while much has yet to be done to complete the sea walls which, as is generally the case along the African coast, have to preserve the ports from being silted up with sand. Extensions are also being made to the port of Djibouti in order to deal with the increased Abyssinian traffic, and last year contracts were given out for the construction of additional wharves. One of the most important undertakings is the irrigation of the Niger valley by the construction of the great Sansanding barrage which has been in hand for several years and is expected to be completed in 1941. It will irrigate land for the cultivation of rice and cotton. The same thing is being done in the Senegal valley, where, it is said, 2,500,000 acres of land will be available for cultivation. The French Government has been carrying out its plans for colonial development methodically, though slowly, in consequence of the vast expense involved, and having done so much to create a unity of economic interest throughout the Empire it cannot contemplate any change in the existing state of things.

The Canal des Deux Mers

The report of a circumstantial character, referred to in this column last week, to the effect that an international group of financiers had undertaken to supply the money necessary for the construction of the Canal des Deux Mers, upon which work would be started at an early date, aroused a good deal of interest and surprise, and nowhere was the surprise greater than at the Ministry of Public Works, by whom we are informed that there is no question of constructing the canal. A demand for a concession to make the canal was presented last year to the Minister, who rejected it. As nothing can be done without his sanction, and as the State would necessarily have control over the canal, the chances of its construction appear to be as remote as ever.

British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

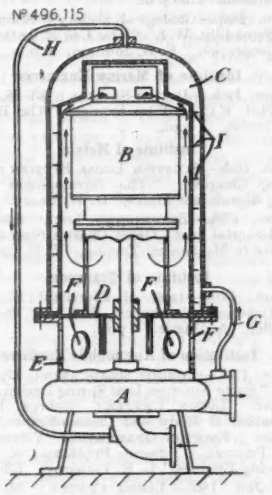
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

PUMPING AND BLOWING MACHINERY

496,115. April 21st, 1937.—IMPROVEMENTS IN SUBMERSIBLE PUMPS, Drysdale and Co., Ltd., Bon-Accord Works, Yoker, Glasgow, and John Whitehead Wilson Drysdale, a director of the company.

This invention relates to improvements in submersible pump units of the type including a centrifugal pump driven by an overhead electric motor housed within an air bell or casing. The pump unit includes a centrifugal pump A and an overhead pump-driving electric motor B housed within a double-walled air bell C presenting between its double walls a jacket space for cooling water to prevent undue temperature rise of the air within the bell. The lower end of the air bell is closed by a diaphragm D which carries a bearing for the vertical shaft connecting the pump impeller with the motor. In order to ensure that the air pressure within C shall be equal to atmo-

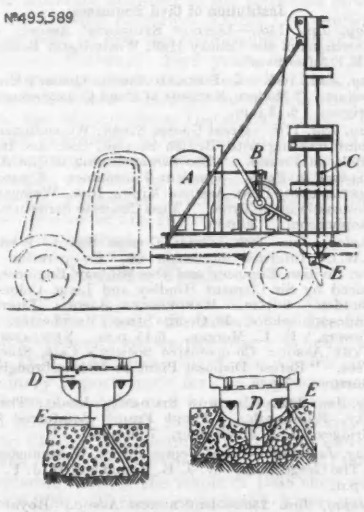


spheric pressure before the bell is submerged, and to accommodate the requisite expansion and contraction of the air under working conditions, vent pipes are provided on the underside of the diaphragm D. The bell C sits on a flanged hollow structure E built up from the pump casing, and laterally bounding a space open to the exterior unit by way of openings F. Cooling water is bled from the discharge side of the pump and delivered into the jacket space by way of a pipe G, after passing through which latter the water is returned to the suction side of the pump by way of a pipe H. Provided within the jacket space are fins I, projecting from the inner wall of the bell and serving to promote spiral or other circulation of the water within the jacket space. The air within the bell is circulated in a closed path through and around the carcase of the motor by a fan mounted on the rotor shaft.—*November 21st*, 1938.

MISCELLANEOUS

495,589. September 7th, 1937.—APPARATUS FOR BREAKING CONCRETE ROADS, James Cowan Hulbert, 37, Wildwood Road, Golders Green, London, N.W.11.

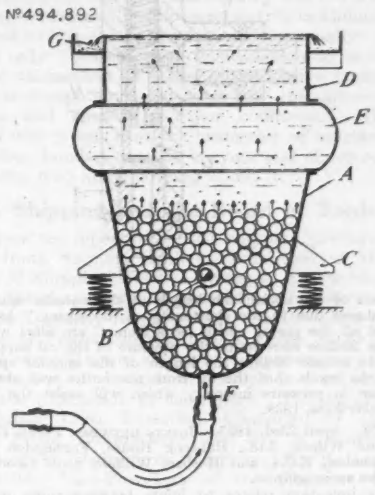
A frame of channel irons is mounted on a motor chassis and carries a petrol or other motor A and a winch B for actuating the drop hammer C. The drop hammer, which is preferably a semi-steel casting weighing about 1¼ tons, has a removable shoe D of mild steel. The lower part of the shoe forming the striking face of the hammer is rounded and in the form of a cross. The shoe has a tapered central hole for the reception of the tapered



stem of a punch E, which projects any distance, depending upon the thickness of concrete to be broken, beyond the striking face of the hammer. It is of cylindrical form and has a flat striking face. When a blow is struck the load is applied over a very small area, and after one or several blows a hole is formed in the concrete, resulting usually in a more or less conical fracture below. Further blows result in the face or shoe of the hammer breaking the concrete adjacent to the hole made by the punch. The apparatus is then shifted on so that the operation is repeated in another position. When a number of rows of holes are made the fracturing of the concrete between adjacent holes is facilitated, cracks usually radiating from one hole to adjacent holes. The use of a drop hammer provided with a small tool facilitates removal of the broken concrete by means of a power shovel, as the fractures being more confined, there is sufficient resistance offered to the shovel to enable it to work efficiently.—*November 16th*, 1938.

494,892. July 11th, 1938.—AN OSCILLATORY WET MILL, Fried. Krupp Grusonwerk Aktiengesellschaft, Magdeburg-Buckau, Germany.

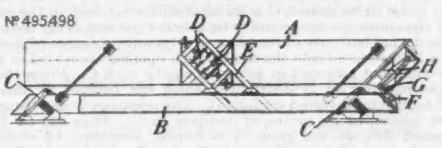
This type of oscillatory mill makes it possible to effect immediately following the grinding process the separation and carrying away of the material which has been ground to a sufficient degree of fineness. A grinding container A is caused to carry out circular oscillatory movements by means of an excentric shaft B. On a level with B are lateral projections C on the walls of the grinding container, by means of which the container is supported upon springs. The container is filled or almost completely filled



with grinding balls. Above the grinding container there is arranged a stationary separating tank D. The connection between the grinding container A and the separating tank D is by walls E made of rubber. The lower portion of the container carries a branch pipe F, which is connected to a water conduit. The inlet aperture of this pipe is covered by a strainer. The mixture of water and ground material flowing over the upper edge of the separating tank is drawn off by means of gutters G arranged in an inclined position at the side of the tank. Water containing the material to be ground is fed into the container and flows upwardly between the grinding elements carrying along with it the finely ground material.—*November 2nd*, 1938.

495,498. July 23rd, 1937.—VIBRATORY SCREENS, Fried. Krupp Grusonwerk Aktiengesellschaft, Magdeburg-Buckau, Germany.

The screening box A is mounted upon the bearer frame B by means of inclined leaf springs, the bearer frame being suspended above the foundations on link members C articulated on pins. Rubber buffers or springs D are mounted on opposite sides of the centre of gravity of the box for the purpose of transmitting vibratory movements from the screening box tothe bearer frame and *vice versâ*, the springs D being mounted in the bridle E, which is attached to the frame and compressed by means of adjusting screws. The bridle is so mounted upon the frame that the line of force exerted by the springs D passes through the centre of gravity of the frame. The link members C are arranged parallel to the leaf springs, so that vibrational movements of the frame are not to any great extent transmitted through the link members to the foundations, but leave the frame free to oscillate angularly in a vertical plane parallel with the plane in which

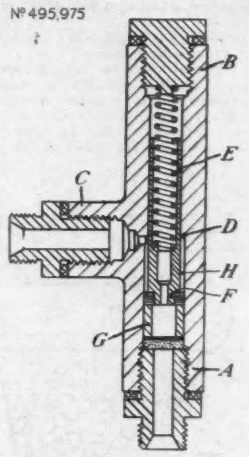


the screening box oscillates. As soon as the plant is caused to vibrate by the rotation of the excentric or other driving member F, the frame and the screening box vibrate in a phase difference angle of 180 deg. in relation to one another, whereby the forces exerted by the masses cancel one another out, as the centres of gravity of A and B lie in a line parallel to the vibratory movement. The driving connection is preferably in the form of a loose coupling, consisting of an excentric secured to a shaft carrying the driving member F and rotating in a bearing associated with a link G, the latter being pivoted to a further link H, which is pivoted to the screening box and is disposed between buffers which absorb any undue vibratory movements of H during the initial stage of building of oscillatory movement of the screening box. In this way the length of oscillatory movement of the box is gradually increased to its maximum. The tare (dead) weight components acting upon the links C are taken up by a spring and transmitted in damped form to the foundations. —*November 15th*, 1938.

495,975. June 8th, 1937.—CENTRAL LUBRICATION, Thomas Winsmore Langley, and Tecalemit, Ltd., both of the company's works at Great West Road, Brentford, Middlesex.

With this device the pressure and pressure variation of the lubricant which is circulated by a pump to lubricate an engine may be used to distribute a limited quantity of the lubricant to other parts. The body member is provided with three branches A, B, and C. In the end of branch A is fitted an inlet union for connection to a lubricant supply such as the engine oil-circulating system. In the end of branch C is fitted an outlet union for connection to the various bearings to be lubricated. The end of branch B is fitted with a closure plug. The body member is provided with two concentric bores of different diameter separated by a shoulder D, the larger bore being in communication with the inlet union of A. Near D, and communicating with the larger bore, is provided a port leading to the outlet union of C. Fitting the two bores is a differential piston comprising a hollow plunger E which fits the smaller upper bore with a degree of looseness to permit oil to leak between the adjacent surfaces, the plunger D being provided with a shoulder and a spigot at its end F. Against this shoulder is fitted a metal washer, between which and a hollow tube G is fitted a sealing ring closely fitting the lower bore. A shoulder is formed in the plunger E, and between this and the top plug is a spring constructed to exert a pressure on the piston opposed to the pressure thereon by the oil from the inlet. The lengths of the various parts are so arranged

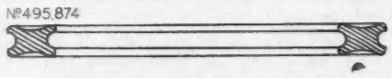
that there will be an annular space H between the inner face of the washer and the shoulder D, and that the differential piston may be forced inwardly against the spring to sweep out the annular space. Oil fed under pressure to the inlet union of A will pass through the central hole in the plunger E and by leakage past the outside of this plunger will reach the annular space H from where it can flow to the outlet of C. When the pressure of the oil is sufficient to overcome the



reaction of the spring the length of the annular space will be reduced due to the shortening of the spring. Assuming H and all the piping which feeds from C are filled with oil, then a further increase in the pressure of the oil supply will tend to reduce further the length of the annular space H, with the result that the oil from the outlet will obtain an increase in pressure intensity which will assist the flow.—*November 23rd*, 1938.

495,874. April 23rd, 1937.—JOINTS BETWEEN PIPES, Babcock and Wilcox, Ltd., Babcock House, Farringdon Street, London, E.C.4, and Herbert William Scott Goodger, of the same address.

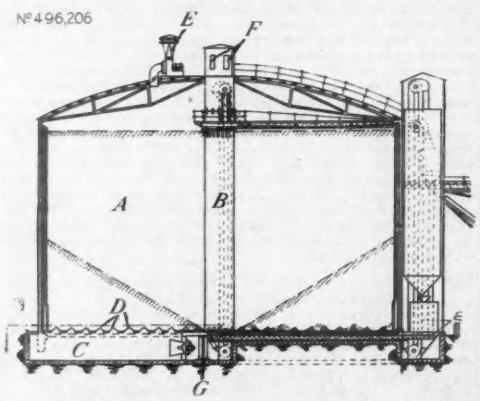
This invention relates to joints between pipes or other members, an object being the provision of a form of joint suitable for use in connection with steam at high pressures and temperatures. It comprises a metal joint ring with concave radial inner and outer surfaces and concave side faces, the concavities being adapted to impart a degre of resilience to the adjacent projecting portions of the ring. The projections of the ring are formed with rounded bearing sur-



faces. In use, since no jointing material is employed, the contacts occurring between metal surfaces, no scraping or cleaning of the surfaces of the ring and flanges is required after a joint is broken and before it is remade, and since the design of the ring is such that permanent distortion or crushing to effect jointing is avoided the ring may be used repeatedly. On account of its inherent springiness the ring is capable of maintaining a good joint, notwithstanding small differences of bolt pressure resulting from unequal tightening of the bolts, and the resilience of the ring enables it to compensate for increase in the lengths of the joint bolts through thermal expansion.—*November 22nd*, 1938.

496,206. February 19th, 1937.—STORAGE OF GRAIN AND OTHER VEGETABLE MATERIALS IN SILOS, Nils Rudolf Martin Weibull, Klostergatan 1, Malmo, Sweden.

This invention relates to apparatus for storing and preserving grain, copra, and other vegetable matter in large quantities. A indicates the container or silo, B is a combined elevator and air drum in its centre, C is an air-distributing duct in the base of the container connected with a boiler for supplying heat to the drying batteries of the plant or adjacent cooling machinery. Air is introduced into the silo through openings provided in the bottom and arranged in a row along the duct C. From these openings the air is distributed along the bottom by means of horizontal inverted troughs D. The openings to the troughs are controlled by means of dampers in C. After the air has passed through the grain, it is caused, according to existing temperature and weather outside the silo, to flow wholly or partly either back through the drum B or out of the silo, for



which latter case a suction fan E is provided on the top of the silo. Substitute air may be supplied through openings F in the drum. The required speed of the cooling air is obtained by means of fans placed in the duct C. The wall of the silo, which is cylindrical in this case, is composed of one outer wall of sheet metal and one inner wall of boards, separated by an insulating layer. For conditioning the air with which the grain is treated there are provided cooling and drying devices G, which are arranged in the path of the air flowing in. If desired, means may be provided for increasing the moisture content of the treating air. When the fresh air needs no cooling the air used may be led away through the suction fan E, substitute air being introduced through openings F and to C. By co-operation of the fans the fall of pressure in the direction from below upwards of increased and therewith also the cooling effect. The design incorporates means for facilitating the filling and emptying of the container and the conveying of the grain to and from the unloading and loading places.—*November 21st*, 1938.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

British Association of Refrigeration

Tuesday, Jan. 17th.—Inst. of Marine Engineers, 85–88, The Minories, E.C.3. Symposium, "Quick Freezing." 6.30 p.m.

Hull Chemical and Engineering Society

Tuesday, Jan. 17th.—Room 51, Municipal Technical College, Hull. "Alchemy, Ancient and Modern," E. H. Hall. 7.45 p.m.

Tuesday, Jan. 31st.—Room 51, Municipal Technical College, Park Street, Hull. "Steam Trawlers," A. Addy. 7.45 p.m.

Illuminating Engineering Society

Tuesday, Jan. 17th.—Inst. of Mechanical Engineers, Storey's Gate, Westminster, S.W.1. "Fourth Report of the Departmental Committee on Lighting in Factories," H. C. Weston, A. E. Iliffe, G. Chelioti, and R. W. Daniel. 7 p.m.

Institute of Fuel

Wednesday, Jan. 18th.—E. MIDLAND SECTION: Railway Inst. Lecture Hall, Derby. "Developments in Oil Refineries," A. E. Dunstan. 7.30 p.m.

Tuesday, Jan. 24th.—Geological Society's Rooms, Burlington House, Piccadilly, W.1. "The Use of Anthracite Duff for Steam Generation," E. B. Johnson. 6 p.m.

Institute of Marine Engineers

Thursday, Jan. 19th.—JUNIOR SECTION: 85–88, The Minories, Tower Hill, E.C.3. Film lecture, "The Boulder Dam," C. M. Roberts. 7 p.m.

Institute of Metals

Monday, Jan. 16th.—SCOTTISH LOCAL SECTION: 39, Elmbank Crescent, Glasgow. "The Development of Corrosion-resisting Aluminium Alloys," G. W. Lacey. 7.30 p.m.

Tuesday, Jan. 17th.—BIRMINGHAM LOCAL SECTION: James Watt Memorial Inst., Great Charles Street, Birmingham. "Practice in Mechanical Testing, V. E. Green. 7 p.m.

Institute of Transport

Tuesday, Jan. 17th.—Inst. of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2. "The Railways and the Trader," A. Hastie. 6 p.m.

Institution of Automobile Engineers

Tuesday, Jan. 17th.—LONDON GRADUATES: 12, Hobart Place, S.W.1. "Some Notes on Leaf Spring Design," P. Aldworth. 7.25 p.m. LUTON CENTRE: George Hotel, Luton. "Unification of Body and Chassis-Frame," W. Swallow. 7.30 p.m. PRESTON GRADUATES: Victoria and Station Hotel, Preston. "Some Problems of High Output and Racing Engines," L. E. Pomeroy. 7.30 p.m.

Wednesday, Jan. 18th.—LEEDS CENTRE: Metropole Hotel, Leeds. "The Use of Gas as a Fuel for Motor Vehicles," S. C. Clarke. 7.15 p.m.

Saturday, Jan 21st.—LONDON GRADUATES: Visit to I.A.E. Research Laboratories, Great West Road, Brentford. 2.30 p.m.

Monday, Jan. 23rd.—GLASGOW CENTRE: 39, Elmbank Crescent, Glasgow. "Factory Experimental Work," A. G. Booth. 7.45 p.m.

Tuesday, Jan. 24th.—BIRMINGHAM CENTRE: James Watt Memorial Inst., Great Charles Street, Birmingham. "Battery-driven Electric Vehicles," R. Tubb. 7.30 p.m.

Friday, Jan. 27th.—GLASGOW GRADUATES: 39, Elmbank Crescent, Glasgow. "Recent Developments in Fuel Injection Equipment," S. R. Williams. 7.45 p.m.

Saturday, Jan. 28th.—BIRMINGHAM CENTRE: Midland Hotel, Birmingham. Dinner and dance. 6 p.m.

Monday, Jan. 30th.—BIRMINGHAM GRADUATES: James Watt Memorial Inst., Great Charles Street, Birmingham. "Modern Automobile Electrical Equipment," E. Scott. 7.30 p.m.

Tuesday, Jan. 31st.—COVENTRY GRADUATES: Broadgate Café, Coventry. "Preparing an Engine for Production, with Special Reference to Methods of Testing," W. H. Wanley. 7.30 p.m.

Institution of Chemical Engineers

Thursday, Jan. 26th.—Inst. of Structural Engineers, 11, Upper Belgrave Street, S.W.1. "Floors for Industrial Purposes," R. Fitzmaurice and F. M. Lea. 6.30 p.m.

Institution of Civil Engineers

Saturday, Jan. 14th.—LONDON STUDENTS' ASSOC.: Visit to extensions of the County Hall, Westminster Bridge Road, S.E.1. (afternoon).

Monday, Jan. 16th.—N. IRELAND ASSOC.: Queen's University, Belfast. "Modern Methods of Road Construction," T. R. Grigson. 6.15 p.m.

Tuesday, Jan. 17th.—Great George Street, Westminster, S.W.1. Joint meeting with British Section, Soc. des Ingénieurs Civils de France. "The Strengthening of the Austerlitz Viaduct in Paris," Monsieur Fauconnier. 6 p.m. NEWCASTLE-UPON-TYNE ASSOC.: Mining Inst., Westgate Road, Newcastle-upon-Tyne. "Mass Concrete Structures," J. A. Stephenson. 7.30 p.m.

Wednesday, Jan. 18th.—Great George Street, Westminster, S.W.1. Informal discussion on "Co-operation between the Civilian Engineer and the Military Engineer," introduced by Sir Clement Hindley and Lieut.-Colonel F. H. Budden. 6 p.m. MANCHESTER ASSOC.: Literary and Philosophical Soc., 36, George Street, Manchester. "Water Towers," E. L. Morgan. 6.45 p.m. NEWCASTLE-UPON-TYNE ASSOC.: Co-operative Society's Café, Stockton-on-Tees. "Refuse Disposal Plant at Middlesbrough," T. V. Burrows. 7 p.m.

Friday, Jan. 20th.—GLASGOW STUDENTS' ASSOC.: The University, Edinburgh. "Fixed Frame Reinforced Concrete Bridges," J. A. MacGregor. 7.30 p.m.

Tuesday, Jan. 24th.—Great George Street, Westminster, S.W.1. "The Gorge Dam," W. J. E. Binnie and H. J. F. Gourley. 6 p.n.

Wednesday, Jan. 25th.—EDINBURGH ASSOC.: Royal Scottish Society of Arts, 16, Royal Terrace, Edinburgh. "Town Planning in Relation to Civil, Municipal, and County Engineering," D. Ross Young. 6.15 p.m. NEWCASTLE-UPON-TYNE ASSOC.: Royal Station Hotel, Newcastle-upon-Tyne. Annual dinner. 7 for 7.30 p.m.

Institution of Electrical Engineers

Thursday, Jan. 19th.—Savoy Place Victoria Embankment, W.C.2. "The Design of Fractional Horse-power Induction Motors," N. F. T. Saunders. 6 p.m.

Tuesday, Jan. 24th.—SCOTTISH CENTRE: North British Station Hotel, Edinburgh. "Electricity in Coal Mines: A Retrospect and a Forecast," R. Nelson. 7 p.m.

Institution of Locomotive Engineers

Tuesday Jan. 17th.—MANCHESTER CENTRE: Literary and Philosophical Soc. 36, George Street, Manchester. "Locomotive Drawing-office Practice," E. C. Appleyard. 7 p.m.

Wednesday, Jan. 25th.—Inst. of Mechanical Engineers, Storey's Gate, Westminster, S.W.1. "A Diesel Train Set with Multiple Axle Drives," H. F. Haworth and T. Hornbuckle. 6 p.m.

Institution of Mechanical Engineers

To-day, Jan. 13th.—Storey's Gate, Westminster, S.W.1. "The Safety Provisions of the New Factory Act," G. Stephenson Taylor. 6.30 p.m. LONDON GRADUATES: Victoria Halls, Southampton Row, W.C.1. Annual dance. 8 p.m.

Wednesday, Jan. 18th.—NORTH-WESTERN BRANCH: 9, The Temple, Dale Street, Liverpool. "Some Aspects and Problems of the Development of High-speed Craft and its Machinery," H. Scott-Paine. 6.30 p.m.

Thursday, Jan. 19th.—MIDLAND BRANCH: James Watt Memorial Inst., Great Charles Street, Birmingham. Annual meeting. Exhibition of films. 6.20 p.m. SOUTHERN BRANCH: Municipal College, Portsmouth. "Sir Charles Parsons and Marine Propulsion," S. S. Cook. 7 p.m. WESTERN BRANCH: Merchant Venturers' Technical College, Bristol. "Mechanical Vibrations," C. E. Inglis. 7 p.m.

Friday, Jan. 20th.—Storey's Gate, Westminster, S.W.1. Papers on "Machine Tool Practice." 6 p.m.

Institution of Structural Engineers

To-day, Jan. 13th.—WESTERN COUNTIES BRANCH: Merchant Venturers' Technical College, Bristol. "A.R.P. and the Structural Engineer," Captain R. Hazzledine. 7.15 p.m.

Wednesday, Jan. 18th.—LANCS. AND CHESHIRE BRANCH: City Technical College, Liverpool. "Road Bridges," R. Heywood. 7 p.m. SCOTTISH BRANCH: 129, Bath Street, Glasgow. "Steelwork in Buildings: Thirty Years' Progress," S. Bylander. 7.15 p.m. S. WALES BRANCH: Baltic Lounge, Swansea. "New Magnesium Works at Swansea," H. G. Hope. 7 p.m.

Friday, Jan. 20th.—MIDLAND COUNTIES BRANCH: James Watt Memorial Inst., Great Charles Street, Birmingham. "Canal Bridges: Notes of Tests on Brick Arches and Reconstruction Schemes," W. M. Veal. 6.30 p.m.

Monday, Jan. 23rd.—JUNIOR SECTION (LONDON): Architectural Assoc., 34–35, Bedford Square, W.C.1. "The Trend of Increasing Legislation Hampers Building," C. Lovett Gill. 7 p.m.

Thursday, Jan. 26th.—11, Upper Belgrave Street, S.W.1. "Floors for Industrial Purposes," R. Fitzmaurice and F. M. Lea. 6.30 p.m.

Iron and Steel Institute

Saturday, Jan. 14th.—Technical College, Newport, Mon. "The Basic Open-hearth Modern Plant and Practice," J. A. Davies. 6.30 p.m.

Junior Institution of Engineers

To-day, Jan. 13th.—39, Victoria Street, S.W.1. "The Voith-Schneider System of Marine Propulsion," E. C. Goldsworthy. 7.30 p.m.

Friday, Jan. 20th.—39, Victoria Street, S.W.1. "Television," H. J. Shaw. 7.30 p.m.

Keighley Association of Engineers

Thursday, Jan. 26th.—Victoria Hotel, Keighley. "The Production, Strength, and Application of the New Alloy Cast Irons," H. A. MacColl. 7.30 p.m.

Manchester Association of Engineers

To-day, Jan. 13th.—Engineers' Club, Albert Square, Manchester. "Trends in Heavy Machine Tool Design and Operation," J. H. Rivers. 7.15 p.m.

North-East Coast Institution of Engineers and Shipbuilders

Thursday, Jan. 19th.—TEESSIDE BRANCH: Cleveland Scientific and Technical Inst., Corporation Road, Middlesbrough. "Railway Signalling and Telegraphing," A. E. Tattersall. 7.30 p.m.

Friday, Jan. 20th.—Mining Inst., Newcastle-upon-Tyne. "Intercrystalline Cracking in Boiler Plates," C. H. Desch. 6 p.m.

Royal Aeronautical Society

Thursday, Jan. 19th.—Inst. of Mechanical Engineers, Storey's Gate, Westminster, S.W.1. "Some Corrosion Problems Relating to Modern Aircraft," A. J. Sidery and J. W. W. Willstrop. 6.30 p.m.

Royal Institution of Great Britain

Tuesday, Jan. 17th.—21, Albemarle Street, W.1. "Chemical Mechanics," M. Polyani. 5.15 p.m.

Saturday, Jan. 21st.—21, Albemarle Street, W.1. "Art and Industry," Lord Gorell. 3 p.m.

Royal Society of Arts

Wednesday, Jan. 18th.—John Street, Adelphi, W.C.2. "Recent Progress in Television," H. L. Kirke. 8.15 p.m.

Wednesday, Jan. 25th.—John Street, Adelphi, W.C.2. "Trade Associations," W. Tudor Davies. 8.15 p.m.

Stephenson Locomotive Society

Saturday, Jan. 21st.—Y.M.C.A., Blackett Street, Newcastle-upon-Tyne. "The L.M.S. Carlisle-Settle Line," N. Wilkinson. 6.30 p.m.

Monday, Jan. 23rd.—Royal Technical College, Glasgow. "The Railways of Ireland," J. F. McEwan. 7.30 p.m.

CALENDARS, DIARIES, &c.

BLACKSTONE AND CO., Ltd., Stamford.—Wall calendar.

JAMES GORDON AND CO., Ltd., Regent House, Kingsway W.C.2.—Wall calendar.

C. ISLER AND CO., Ltd., Bear Lane, S.E.1.—Wall or desk calendar with daily tear-off sheets.

A. AND J. MAIN AND CO., Ltd., Possilpark, Glasgow.—Wall calendar.

MARSHALL, SONS AND CO. (SUCCESSORS), Ltd., Gainsborough.—Wall calendar.

JACK OLDING AND CO., Ltd., 101, Grosvenor Road, S.W.1.—Wall calendar.

PECKETT AND SONS, Ltd., Bristol.—Wall calendar.

H. J. SKELTON AND CO., Ltd., 16, Finsbury Square, E.C.2.—Daily wall calendar.

STANTON IRONWORKS COMPANY, Ltd., near Nottingham.—Pocket diary.

ROBERT STEPHENSON AND HAWTHORNS, Ltd., Forth Bank Works, Newcastle-on-Tyne.—Wall calendar with daily tear-off sheets.

A Seven-Day Journal

Forth Road Bridge

AT a meeting of the Forth Road Bridge Committee, held in Edinburgh at the end of last week, the proposed road bridge across the Forth was discussed in relation to certain technical matters. Mr. Henry Steele, the Lord Provost of Edinburgh, made an interesting statement which was approved by the Committee. He said that the engineer, Dr. Anderson, had informed him that the Admiralty raised no specific objection to the Mackintosh Rock site for the bridge, and that scheme accordingly stood confirmed as far as the Admiralty interest was concerned. In connection with the Beamer Rock site, suggested by the Forth Conservancy Board, the engineer estimated that the blasting of the rock would cost between £200,000 and £300,000. As the figure was a prohibitive one, that scheme could be considered to be disposed of. He referred also to the matter of the alternative designs and methods of constructing the bridge which might be adopted, and said that in the view of the engineer a stiffened suspension structure was the only type of bridge which could economically be adopted. This view accorded with the opinions expressed in a communication which the engineer had received from the Ministry of Transport. The type of structure to be adopted appeared therefore to be beyond question. The Lord Provost also referred to the possibility of driving a tunnel under the Forth. He had, he said, received a report on that matter from the engineer, giving information with regard to the difficulties likely to be encountered owing to the differing strata and the presence of fissures. From the point of view of the Committee, the proposition seemed to be beset with both practical and financial difficulites.

London's Underground Water

A MEMOIR issued last Monday by H.M. Stationery Office and entitled "Water Supply of the County of London from Underground Sources," was prepared by the Geological Survey of Great Britain and gives particulars and records of over 1000 wells in the London area, together with geological and historical descriptions of the area concerned. As much as 11½ per cent. of London county's water comes from underground sources. It is now generally known that the water level below London is becoming steadily lower. The memoir states that the water is being extracted more rapidly than it can be replenished by the extremely slow flow possible under existing subterranean conditions. There are now twice as many wells in operation, it is stated, as in 1911. What happens at the outcrop of the chalk is of much less immediate importance, but it is pointed out that a considerable number of new wells have been bored in that situation and are removing large quantities of water which otherwise might travel towards the centre of London. Also land drainage over the surface of the outcrop has been rendered more effective, and the amount of water available for absorption in the underground strata reduced. In addition, extensive building over the areas outside London, where the chalk comes to the surface, has diminished the catchment, thus extending outwards the distance through which the water absorbed must travel to reach the centre of the London basin. Finally, the amount of rain contributed to the chalk and sands has been seriously decreased during recent periods of drought. Most of the factors which have reduced the level of the water are likely to continue to exert an influence in preventing the recovery of the water levels and perhaps will further depress them.

Chinese Apprentices in British Firms

ON Wednesday, January 18th, there arrived in London six young Chinese engineers who have come to this country to receive practical training in engineering works under the scheme of scholarships operated by the Federation of British Industries. They were welcomed by Lieut.-General Sir George Macdonogh, the chairman of the F.B.I. Chinese Apprentices' Committee. They form a part of a group of twenty-one apprentices selected from 120 applicants by the F.B.I. Sélection Committee in Shanghai, which consists of prominent local engineers. They have been selected on the basis of technical qualifications, personality, knowledge of English, and general fitness, and are graduates in engineering of approved universities in China or Hong Kong. The scheme, which has now been in operation for five years, and under which fifty-seven scholarships have already been awarded, is intended, apart from fitting these apprentices for responsible engineering positions in China, to develop trade and cultural relations between China and the United Kingdom. The scholarships are financed by grants from the Universities' China Committee in London, the Board of Trustees in China for the Administration of the British Boxer Indemnity Funds, and the British Council in London, and maintenance allowances are paid by the engineering firms concerned. In addition, passages at specially reduced rates are provided by the P. & O. Company, London, and Alfred Holt and Co., Liverpool, while the scheme is administered free of charge by the Federation of British Industries. Scholarships are tenable for one year, but may be extended for a second year where satisfactory progress is shown. Twenty-nine apprentices have completed their training and have returned to China, and contact with them is maintained notwithstanding the present very disturbed conditions in that country. Some are practising their profession in Shanghai and Hong Kong, but the majority are engaged on construction work in West and South-West China under the Chinese National Government.

The Scottish Special Areas

THE Commissioner for the Special Areas in Scotland, Lord George Douglas Hamilton, recently announced that during December last he entered into further commitments amounting to about £7000 for social and economic development in the areas. Of this amount, over £3300 relates to a scheme of sewerage and sewage disposal, and a water supply scheme, estimated to cost £6000 and £4000 respectively, both to be undertaken by the Linlithgow Town Council. It is also stated that assistance has been offered for the establishment of a new industrial undertaking in the Scottish special areas. Thirty-seven offers of assistance for the purpose of inducing the establishment of industrial undertakings in the areas have been made since May, 1937, when the Special Areas (Amendment) Act, 1937, came into force. These undertakings have an aggregate capital of over £1,334,000, and are expected to give employment to about 2520 persons. Five of the applications for assistance under consideration have reached an advanced stage. If these applications result in the establishment of new industrial undertakings, it is estimated that capital totalling £74,500 will be provided and over 170 additional persons will be employed. Seventy-seven leases have been signed on the Hillingdon Industrial Estate and another twenty-six factories are bespoken. Sixty-one firms are now in occupation and 1257 persons employed. In connection with this and the three Lanarkshire Industrial Estates, 750 persons are employed in the work of laying out. The Commissioner's total commitments adjusted to date amount to approximately £4,913,000, involving a total expenditure of about £8,883,900. This last figure does not include the capital brought into the areas by the new firms being established on the industrial estates and elsewhere in the areas.

Director of Air Ministry Factories

IT is announced that the Secretary of State for Air has appointed Mr. Arthur R. Cooper to be Director of Air Ministry Factories in the Department of the Director-General of Production. Mr. Cooper, it will be recalled, retired from the post of Chief Engineer to the London Passenger Transport Board in December, 1937, after thirty-seven years of service with the Underground Railways. In his new office he will be particularly concerned with the supervision of national factories and the extensions of makers' works which are erected at the cost of public funds and are managed by the various companies for the Air Ministry. He was educated at Magdalen College School, Oxford, after which he passed through the workshops and drawing-offices of the Great Western Railway Company at Swindon. Between 1899 and 1901 he was assistant engineer at the Deptford power station of the London Electrical Supply Corporation, and left that post to join the engineering staff of the Central London Railway. Five years later he was appointed Superintendent of the Bakerloo Line, and in 1908 his duties were extended to include that of Engineer to the Metropolitan District Railway. He became Chief Engineer to several lines when the London Underground Railways were linked up, and, on its formation in 1933, he became Chief Engineer to the London Passenger Transport Board. Mr. Cooper is a member of the Institution of Civil Engineers and of the Institute of Transport.

Foreign Trade

AT the first B.E.A. luncheon of the year on January 12th, Mr. David Bremner, the Director addressed the company under the title "What Confronts us in 1939." He opened with the remark that "the machinery export trade for the last two years has really been the bright spot in the export trade of the United Kingdom." In 1937 machinery exports amounted to £49,750,000 sterling; in the first eleven months of the following year they rose to £52,841,000, and it is probable that for the whole of 1938 they will reach £58,000,000. Of these exports 57·5 per cent. went to British countries. But there was more anxiety about the immediate future. Foreign trade is essential to us as a nation, and since it is very closely allied with the shipping industry, Mr. Bremner thought engineers ought to support "the very reasonable proposals which are to be put forward by the shipping industry for coping with the very serious conditions with which that industry is faced." The Government should be induced to do anything that may be in its power to ensure that the maximum proportion of our coastal trade is carried in British bottoms. "When we make trade agreements," he asked, "why are we in such a position of impotence that we cannot insist that a very much larger proportion of the cargoes shall be carried in British ships?" He suggested that there was a lack of trade organisation and that this country was too slow in reaching decisions. The Government, he continued, is prepared to help the industries—not financially—if they will only "perfect their organisations so as to constitute themselves as really authoritative bodies who will be competent negotiators with the different industries and trades in other countries." He wondered why it was that the leadership of industry was so often handed over to lawyers and chartered accountants, who knew nothing about it.

British Shipping and the Board of Trade

LAST week the report on British shipping, prepared by the Joint Shipping Policy Committee of the Chamber of Shipping and the Liverpool Steam Ship Owners' Association, was submitted to the Government. On Tuesday, January 17th, the President of the Board of Trade, the Right Hon. Oliver Stanley, received a deputation of shipowners representing the various sections of the industry which had collaborated in the production of the report. The deputation included Lord Essendon, Chairman of the Shipping Policy Committee; Mr. W. A. Souter, President of the Chamber of Shipping; Mr. Robertson F. Gibb, Vice-President of the Chamber of Shipping; Sir Herbert Cayzer, Chairman of the Shipping Committee of the House of Commons; Mr. Philip Runciman, Chairman of the Documentary Committee; Mr. W. Guy Ropner, Chairman of the Deep Sea Tramp Section; Mr. R. March K. Turnbull, Chairman of the Tramp Policy Committee; Mr. G. P. Christopher, Chairman of the Tramp Shipping Administrative Committee; Mr. F. Ll. Hunting, Chairman of the Tanker Section; Mr. A. O. Lang, representing Sir William Currie, Vice-Chairman of the Liner Section; Mr. L. C. Harris, Chairman of the Coasting Fact Finding Committee; Captain J. Fisher, Chairman of the Coasting and Home Trade Tramp Section; Mr. K. Kelso, Vice-Chairman of the Coasting and Home Trade Tramp Section; Mr. Philip Haldin; Mr. Alfred Woods, Chairman of the Liverpool Steam Ship Owners' Association; Mr. Fletcher Hunt, Vice-Chairman of the Liverpool Steam Ship Owners' Association; Colonel Denis H. Bates, and Mr. W. R. Roberts. The proposals made were elaborated and the President asked for further information on some points. In his reply, he made acknowledgment of the extensive work which had been done in the preparation of the report, and renewed his assurance that he would give full consideration to the industry's inquiry and the report, in the knowledge of the importance of the industry and the need for a prompt consideration of the problems with which it was faced.

The Kingston Power Station Fire

THE public inquiry into the cause of the fire at the Kingston-on-Thames Corporation Electricity Works on December 14th, which resulted in the failure of electricity supplies throughout a wide area, was resumed at the Kingston Guildhall on Monday last and concluded on Tuesday. An agreed statement on the circumstances in which the breakdown occurred was submitted by the Town Clerk, Mr. A. W. Forsdike, on behalf of the Kingston Corporation, the Central Electricity Board, and the General Electric Company. It stated that in order to carry out the complete work of modifying the various switching units, it was necessary to test the alignment of each new circuit breaker, and to do this it was, of course, essential that all contacts should be made dead and efficiently connected to earth. During the week previous to the fire, Mr. G. H. Gould, an erector in the employ of the contractors, had successfully taken the latter precaution by employing an earthed conductor at the end of a stick and subsequently carried out the alignment test. On December 14th, he attempted to take the same precaution in connection with work on another C.E.B. 11,000-volt unit which, unfortunately, proved to be alive. The result was a disastrous fire which caused considerable damage and gave rise to a long interruption in the supply. In reply to Mr. J. Hacking, Deputy Chief Engineer of the Central Electricity Board, Mr. Gould said that he was entirely familiar with the permit to work as applied by the Board, but he took the work card he received to cover more than it actually did. He had done work on Kingston and Walton transformers on a single permit, and previous conversations and events had led him to believe that the switch unit that caused the disaster was dead. Apparently, at the time of the fire, the protective gear had been removed from the switch.

A History of Rotary Engines and Pumps

No. II

(*Continued from page 45, January 13th*)

THE DAYS OF WATT.[1]

IT was towards the end of the eighteenth century that engineers in general first became infected with the "rotary fever," as was mentioned in the introductory article of this series, and it was Watt himself who first thought of a rotary engine. Some years before his partnership with Boulton began he first conceived the idea, at a time when he was still engaged upon surveying work, but was being supported financially and encouraged to press forward with his main invention by Dr. Roebuck. He was already, however, in contact with Boulton and Small. The first mention of a rotary occurs in a letter to Roebuck in February, 1766: "I have thought on a simpler circular steam engine than what I mentioned to you, and which I expect will be practicable." He was so much pleased with the idea that he worked on this engine for several months, and found that there was a great deal more trouble in making a model than he had expected. The engine was patented in 1769 in the same specification which included his main invention, the separate condenser. He had prepared a drawing for this specification, but Boulton and Small advised him not to file it, and it is fortunate that it has been preserved—Fig. 8. Nothing,

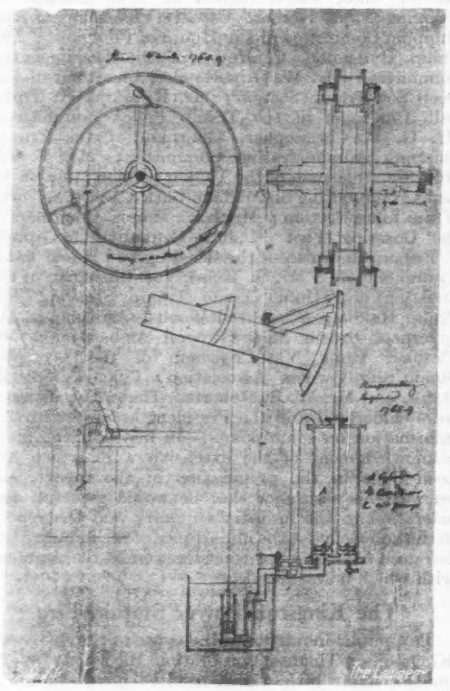


FIG. 8—WATT'S UNFILED DRAWING FOR THE 1769 PATENT

however, seems to have been done at this time, and a year later we find that Watt's mind has run off at a tangent. He suggests a machine consisting of a "right and left-hand bottle screw spiral involved in one another," a scheme claimed by some to be for a turbine, but which sounds very much more like two intermeshing right and left-hand screws with a suitable casing, something like the modern screw pump made by Stothert and Pitt, of Bath. Even when work upon building the circular engine was begun, it was not hurried, probably because of the more urgent demands of the pumping engine. The machine seems to have been completed about 1771, but in August, 1772, there is a record that it was still awaiting quicksilver from London, and it was not till 1774 that it was actually got to work. Its construction is revealed by a drawing in the Doldowlod Papers, reproduced in Fig. 9 from "James Watt and the Steam Engine," by Dickinson and Jenkins. The drawing was prepared by Watt to be laid before the Committee of the House of Commons which considered the Bill for the extension of his original patent. In evidence it was stated that the actual wheel constructed at the works was 6ft. in diameter and weighed upwards of a ton.

[1] Based on "James Watt and the Steam Engine," by Dickinson and Jenkins and various other well-known sources.

The wheel consists of an annular chamber mounted on a shaft, and, as is inscribed upon the drawing in Watt's handwriting, "the arms of the wheel are not shown, to prevent confusion." Within the annular chamber there are three "valves" hinged to its outer periphery and adapted to close off the passage completely. In the lower part of the chamber the passage is blocked by a pool of mercury. Three pipes are led from the axle to the chamber, each terminating just behind one of the "valves." The end of the shaft abuts against a "nozzle" shown in detail in the drawing, which has two part-annular openings, through one of which steam was supplied, whilst exhaust took place through the other. By the rotation of the wheel the ends of the pipes were brought successively opposite the steam and exhaust ports in the "nozzle." Steam was supplied to the annular chamber formed by the walls of the wheel, one of the valves, and the face of the mercury, and the mercury being driven up to a level consistent with the steam pressure and vacuum conditions, acted as an abutment, so that the wheel was forced round. The valves lifted in their downward travel to pass through the mercury.

This engine, it will be observed, is, in fact, Amontons' "Moulin-a-feu," adapted for use with steam instead of air, and purified of its crude means of supplying heat and cold. Its efficiency is limited by the small pressure range which is settled unalterably by the diameter of the wheel. As Watt constructed it, the nozzle could have been so formed that expansion of the steam would have occurred in the annular chamber, but any such arrangement would have required the mercury to oscillate in accordance with the changes of pressure. Expansion was not used. These defects of the wheel were, however, not important at the time of its invention, and it was the practical difficulty of constructing it which eventually led to the abandonment of the machine.

Boulton and Small were both confident that the device would prove successful, but Watt seems to have begun to lose faith in the idea even as early as 1772, before the engine was got to work. At least one other engineer of the day had no doubts whatever on the matter. Smeaton, in 1773, told Watt to "push" the condensing engine; but "the circular engine would not do." Nevertheless, Boulton remained confident. In 1775, he informed a correspondent in reply to a query for an engine, "We have two sorts of steam engines, viz., the reciprocating engine, which is particularly applicable to the raising of water to mills or out of mines, of which kind we have one in constant work at Soho. . . . Secondly, our steam wheel or rotative engine is particularly applicable for all the purposes which water wheels and horse mills are apply'd, and it is of that species of engine that your friend wants, but we are less prepared to speak positively of prices of the rotative engine than we are of the reciprocating engine, having only executed one to satisfy ourselves of the practicability and utility of it, but have now another in hand which will enable us to be more precise in every point relative thereto. I can only say in general terms that it may be apply'd conveniently and advantageously to the working of a silk mill, that the price will be in proportion to its power, and that its power has no limits but that of price, so that the steam wheel may be made equal in power to 2 horses, 4, or 8 or any number, and the diameter about 9, and in no case will exceed 11 feet."

It is clear that Boulton at this date was fully confident that the wheel engine would prove successful. Indeed, he was so sanguine of its success that he proposed the works should turn out fifteen reciprocators and as many as fifty rotaries each year. Not until 1776 is there any information as to the performance of the machine. Then in a letter to Henderson, Boulton says that the last wheel they executed had a power equal to three horses, and that as far as fuel consumption was concerned: "One hundredweight of the slack or small coals from Wednesbury coalpits apply'd to our wheel engine, will raise 30,000 cubic feet of water 30 feet high, but ought to raise 36,000, and I doubt not when our workmen are a little more expert in execution that we shall raise the latter quantity." One of the defects of the machine, though Boulton did not realise it, had become apparent. There was too much friction and too much leakage and no increased expertness in execution could overcome those disadvantages. In 1777 the wheel engine was still at Soho, and as late as 1779 patterns for parts of a wheel were sent to Williamsons's foundry at Bradley. Even after ten years' experience with it Boulton and Small still felt that the chances of the machine commercially were superior to those of the reciprocating engine. But Watt was rapidly losing faith in it, and by 1780,

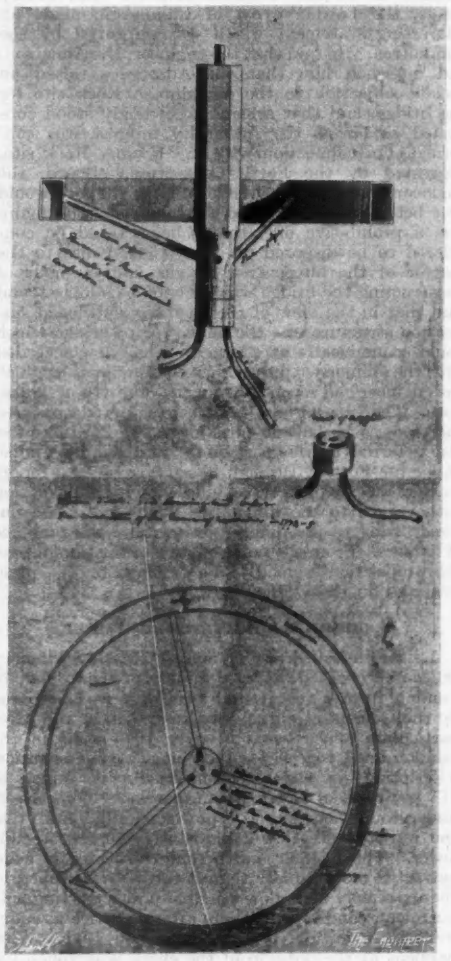


FIG. 9—WATT'S DRAWING OF THE "STEAM WHEEL"

or perhaps a year or two later, it was definitely discarded.

The firm of Boulton and Watt had, however, not yet done with rotary engines. In 1782 Watt patented another form of rotary engine which consisted of a thick plate mounted at one edge on an axle and adapted to turn in a cylindrical casing fitting closely around it. An "abutment" was hinged to the casing and bore against the

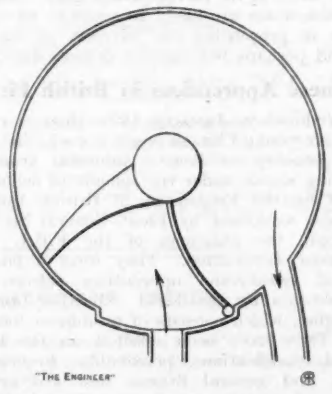


FIG. 10—WATT'S ROTARY ENGINE OF 1782

axle at the outer end. Steam was admitted—Fig. 10—on one side of this abutment and exhausted from the other. But there does not seem to be any evidence that Watt carried out any further experiments with the device, and there are distinct suggestions that the machine was patented with the object of discouraging one of the firm's workmen from expending further time on developing the idea.

Cameron.—The workman referred to in the

preceding paragraph was named Cameron. He first approached Watt with his idea for making a rotary or perhaps a semi-rotary engine, but Watt informed him that he had himself thought of the same engine some years before and had even made a model of it. As, however, the model was not to be found, Cameron refused to be discouraged. He next approached Boulton, whose faith in rotary engines had not yet been shaken. Boulton without firstly consulting Watt, who would no doubt have refused it, gave Cameron permission to work on the idea. As Watt expected, Cameron's efforts to achieve success proved uniformly unavailing, and his persistence became an annoyance. Discouragement having effected nothing, Boulton and Watt appear to have taken the somewhat extreme step of patenting in 1782 precisely the rotary machines on which Cameron was working. The patent and the original model made by Watt which Boulton had in the meantime discovered, were exhibited to Cameron, who, much incensed, declared roundly that Watt was not the inventor. Despite his insulting behaviour (for which one is inclined to remark there seemed to be considerable justification) Cameron was allowed to remain at the works and was even permitted to work at intervals on his engine. But in 1783 the matter was at last put a stop to and Cameron seems to have left the firm.

In a patent dated 1784, Cameron, who had by then left Boulton and Watt, describes a machine much like Watt's, but having two reciprocating abutments instead of the single hinged flap, and, in addition, an interesting machine, the rotor of which consists of a deep helix right hand for half a turn and left hand for the rest, so that it completely encircles the shaft. This rotor A is contained—Fig. 11—in a cylindrical case the

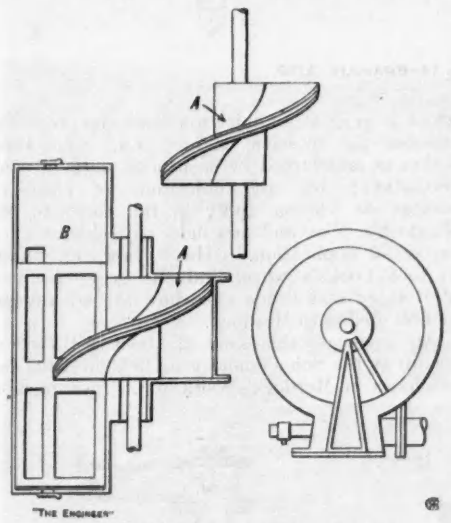


FIG. 11—CAMERON'S HELICAL MACHINE

same diameter as that over the top of the helix blade. Into one side of the chamber projects a "sliding frame" B fitting over the helix and capable of moving up and down as the helix turns, thus acting as an abutment. Steam is admitted through the frame, which is adapted to act as a slide valve, and may be caused to act on both sides so as to give a continuous impulse towards turning the helix. Unfortunately, the device infringed Watt's patent, as a condenser was to be used.

Hornblower.—Among the more notable of the engineers of Watt's day who were taken with the rotary fever was Jonathan Hornblower, the inventor of the compound engine, and a rival who gave Watt much trouble. His rotary, which was patented in 1781, is remarkable for the ingenuity, both of its conception and its construction, and is illustrated in the drawing, Fig. 12, reproduced from Farey's "Steam Engine." Two hollow leaves A and B are mounted together like the hinges of a door within a cylindrical casing concentric with their axles. The axle of one leaf projects through the hollow centre of the axle of the other leaf, so that the leaves can move independently. The interior of that leaf which is mounted on the longer axle is supplied with steam through a passage in the axle, whilst the interior of the other leaf is similarly connected with the exhaust. One leaf has mushroom valves arranged in each of its faces and adapted to lift outwards, and the other has similar valves lifting inwards. The two valves on each leaf are so interconnected that if one is open the other must be closed. In action the leaves were intended to move alternately, that which was at first in front circling round the containing cylinder till, on reaching a position behind the other, it was held stationary while the second one moved. To render this action automatic the valves were constructed with projecting tails so situated that as the moving leaf approached the stationary one the tails contacted and the valves were thereby reversed, those that were before open being closed, and those that were closed opened. By this means that steam valve was opened which would admit steam to the small space between the leaves, and that exhaust valve which would allow the used steam in the larger sector to flow away.

The means devised for preventing the leaves turning back when the valves were changed over is shown by a detail drawing. It is a form of free-wheel mechanism. Two short levers N on the end of the axle are connected by short links to peculiarly shaped pieces M able to move in an annular groove. The pieces are circular on their outer sides, and fit the outer radius of the groove. Thus if the rotation is such that they are "pushed" by the links, they can slide freely in contact with the annulus. But if an attempt is made to "pull" them, their leading ends connected to the links will be drawn inwards away from the outer radius of the groove and, owing to their peculiar shape, their tails will jam against the side of the annulus, rendering them immovable. Similar devices are arranged between the two axles of the machine and the main driving axle, so as to convert the intermittent motion into a continuous one. Steam is admitted through a square port cut in one of the hollow shafts. To allow for throttling a slider *r* is mounted on the shaft, and, having a circular rack cut on its outer periphery, it can be moved to cover or uncover the port by means of a pinion.

The edges of the leaves within the cylinder were packed with hemp in grooves constructed to retain it, and confined by plates screwed against the surfaces of the leaves. The spindle of the machine was placed vertically, and the weight of the moving parts was carried on a pivot in a brass socket borne up by a regulating screw.

Stuart says of this machine: "Mr. Hornblower made many attempts to bring this ingenious project to bear, but the engine could not be made to answer on account of the friction and leakage of the packing which is more than twice as much as is required in a common engine exerting the same force, because the leaf which is immovable, and which answers to the bottom of the cylinder, is packed and exposed to leakage, as well as the acting leaf. The stopping and starting of the piston was always attended with a violent jerk, and the clamps to prevent the retrograde movement were very subject to wear out of order, and then to break or run back."

Bramah.—This engineer, one of the greatest

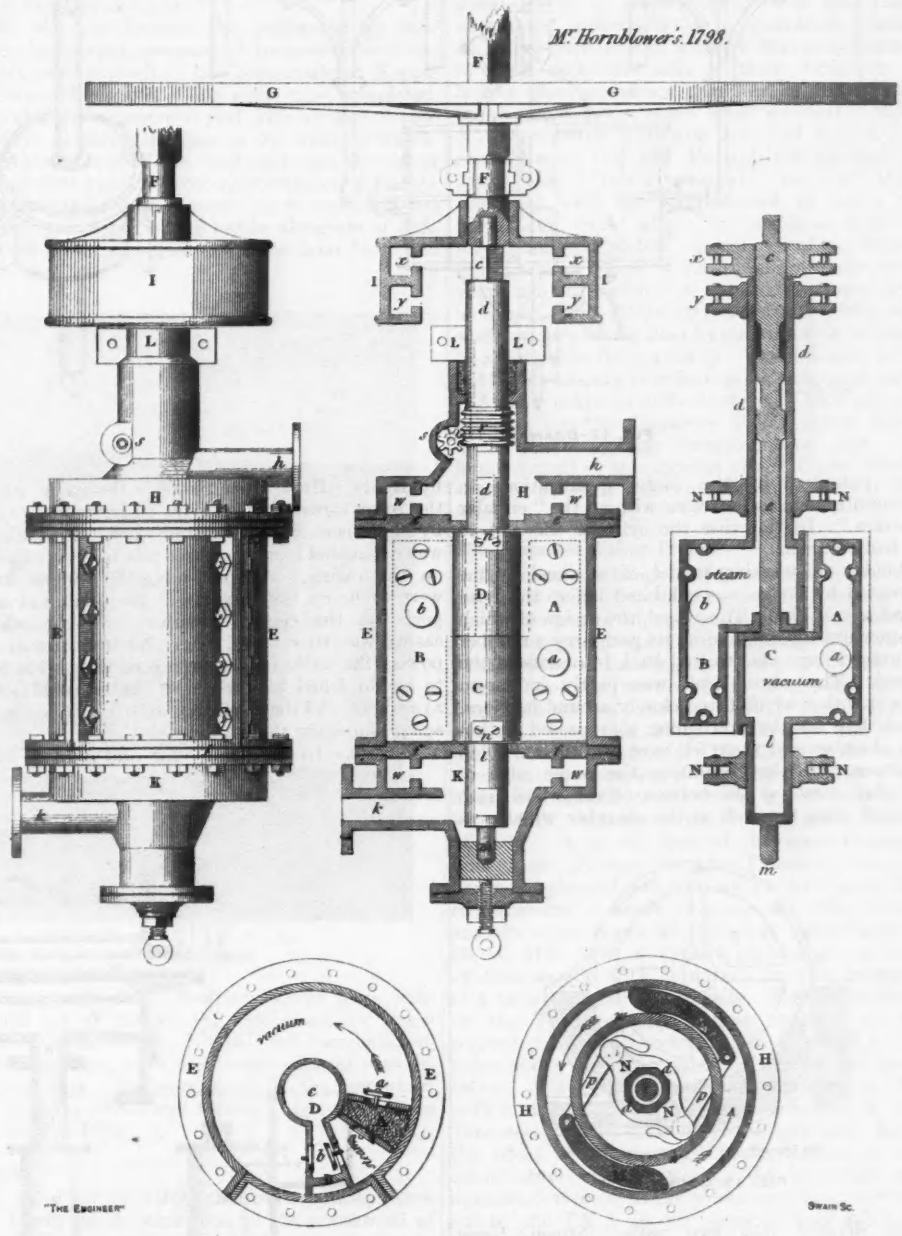


FIG. 12—HORNBLOWER'S ENGINE, 1781

mechanics England has ever produced, the inventor of the lock which bears his name and of the hydraulic press, also tried his hand at the design of a rotary engine. His first patent in 1785 included a machine very much like that described in Watt's patent specification of 1782. The hinged abutment was to be closed by weights. Another had a sliding block on the cylinder actuated by a rack and sector wheel. Bramah thought of using rotary engines "to working ships that are becalmed and at a stand for want of wind." His specification of 1790 includes two rotaries, which are shown in Fig. 13 and 14. The first consists of a "piston" mounted upon a drum, and able to travel around in a cylindrical casing. Two reciprocating abutments A project from the walls of the casing towards the drum, and are operated from an external guide ring B mounted on the shaft, so that one is closed while the other is open to let the piston pass. The steam

and exhaust ports are one on each side of the piston, being fed by passages in the axle. The second design—Fig. 14—consists of a hollow drum placed excentrically in a casing and having two blades projecting across it on diameters at right angles, and fitting against the walls of the containing cylinder. The drum itself is not in contact with the cylinder, but with a "circular division" C within the casing. As the object of the "circular division" can only be to compensate to some extent for the difference in length of blade required on the two chords of the cylinder, due to the excentricity, it is interesting to find that Bramah is the true criticism of this machine, which, in the small length of the sector over which the seal had to be good, shows to advantage in comparison with many others.

Ridge.—The invention of the gear pump and corresponding engine is, apart from the Pappenheim machine, frequently ascribed to Murdock, the assistant of Watt. But in 1791, eight years before Murdock filed his patent, Ridge proposed several gear designs, including one with six teeth on each wheel, another with three teeth and external gears, and a third almost precisely similar to the machine invented seventy-five years later by Roots. He also suggested a design in which the rotor carried hinged flaps to be driven round by the steam, which entered upon one side and was exhausted from the other side of an abutment on the casing. Alternatively, the hinged flaps were to be on the casing and the abutment and ports on the central member, and the whole casing was to revolve. For the transmission of power, the outer circumference of the casing was to be furnished with teeth, so that it could serve as a wheel. All these schemes were to be reinvented again and again thereafter.

Rumsey.—In the same year and a little later than Ridge, Rumsey proposed an engine consisting of "two wheels of metal exactly circular or elliptical with hollows and rounds, *i.e.*, coggs," which were to intermesh and be driven around by the steam. Rumsey also proposed a preponderating weight wheel in 1788, the heavy fluid being driven out along curved tubes to the edge of the wheel by the force of the steam.

Murdock.—Murdock has better-known claims to recognition as a fine engineer than those provided by his rotary engine invented in 1799. It consisted of two gears (Fig. 16) each having six teeth and intermeshing together. Steam was admitted through a mushroom valve and was exhausted to a separate condenser Q mounted below the machine. The date and the use of the separate condenser suggest that he may have delayed application for a patent until Watt's patent of the condenser ran out its time. The drawing is taken from Farey's "Steam Engine." The air pump for the condenser was driven by a crank from the main shaft. Each tooth of each gear carried in its head and around its flank a layer of packing in a slot. There were no external gears to keep the two rotors in correct angular relationship and to prevent wear of the contacting faces, and power was drawn off from one of the two shafts. Farey gives credit where it is due: "Mr. Murdock's engine would be free from the defect which is so great an objection to all the preceding schemes for rotative engines, viz., that their action is interrupted or suspended once in each revolution; but the objections of excessive leakage or friction apply in full force to Mr Murdock's plan and preclude any chance of a successful application." He is, however, unfair in that Cooke's wheel and the gear machines of Rumsey and Ridge also show the advantages he first credits to Murdock.

An engine of this kind of about ½ H.P. was set up at the Soho Foundry in 1802 to drive the machines in Murdock's workshop. In a memoir of the life of Murdock presented before the Institution of Mechanical Engineers in 1850, Mr. Buckle, of Soho, said that the engine remained in the workshop thirty years. He actually exhibited the machine to the meeting.

(To be continued.)

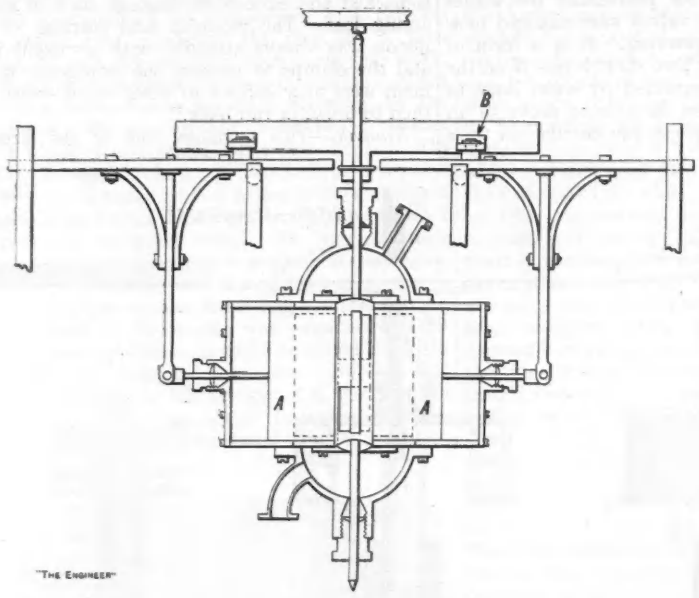


FIG. 13—BRAMAH, 1790

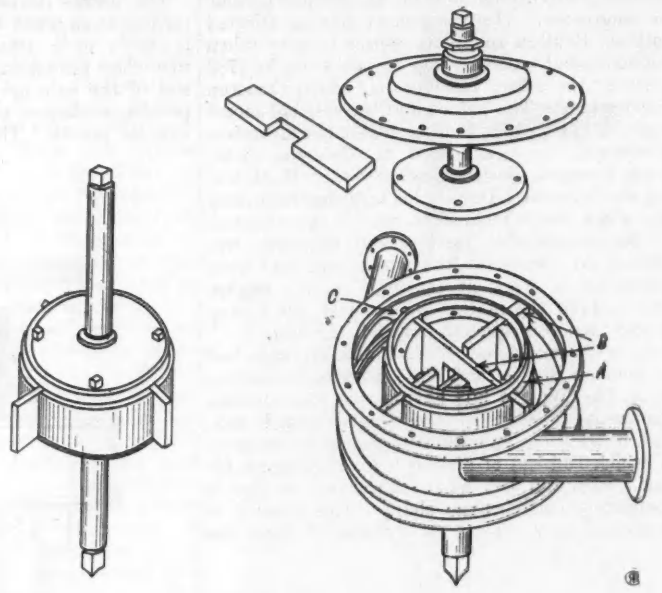


FIG. 14—BRAMAH, 1790

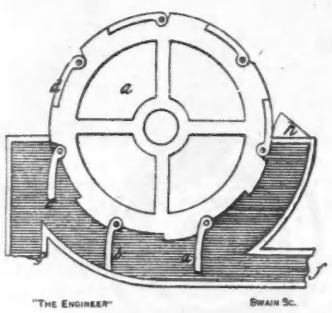


FIG. 15—COOKE, 1789

thus divided into two parts. Steam being admitted to one part from the passage *f*, the wheel was driven round until, folding back, the flap re-emerged from the chamber, whilst the steam passed to exhaust. There were sufficient flaps to ensure that there was always at least one between the steam and exhaust sides of the chamber. Partington in his "Steam Engine" says of the model exhibited to the Irish Academy: "In this instance it must have acted as a high-pressure engine, discharging the steam at each division of the wheel; and we very much doubt whether it would be possible to pack the hanging valves sufficiently tight to admit of their readily falling to the position described by Mr. Cooke." According to Stuart, "Cooke made his flaps to have an area of 36 square inches, and thought his wheel would be forced round with a force equal to 531 pounds!" The exclamation mark is Stuart's, and seems unnecessary. The pressure difference, not accounting for friction, works out at only 14·7 lb. per square inch. Partington's

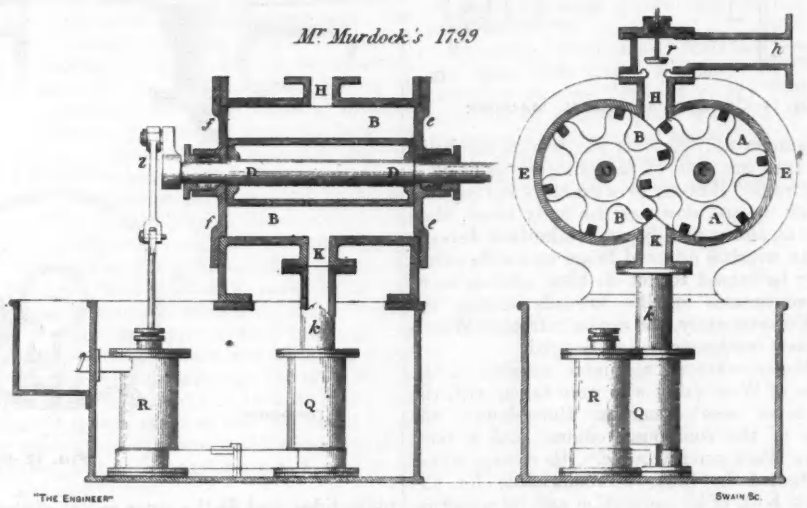


FIG. 16—MURDOCK'S GEAR ENGINE, 1799

ASSISTANCE FOR SHIPBREAKING FIRMS.—It is reported that the British Iron and Steel Federation is considering a proposal to grant a premium to British shipbreaking firms to enable them to compete with foreign concerns receiving subsidies. These subsidies enable foreign shipbreakers to quote prices up to 25 per cent. more than the companies in this country when purchasing vessels for breaking up. Although there is no urgent need for scrap metal, the idea is to keep the shipbreaking yards at work.

Harbours and Waterways in 1938

No. III

(*Continued from page 49, January 13th*)

THE EAST

Ceylon

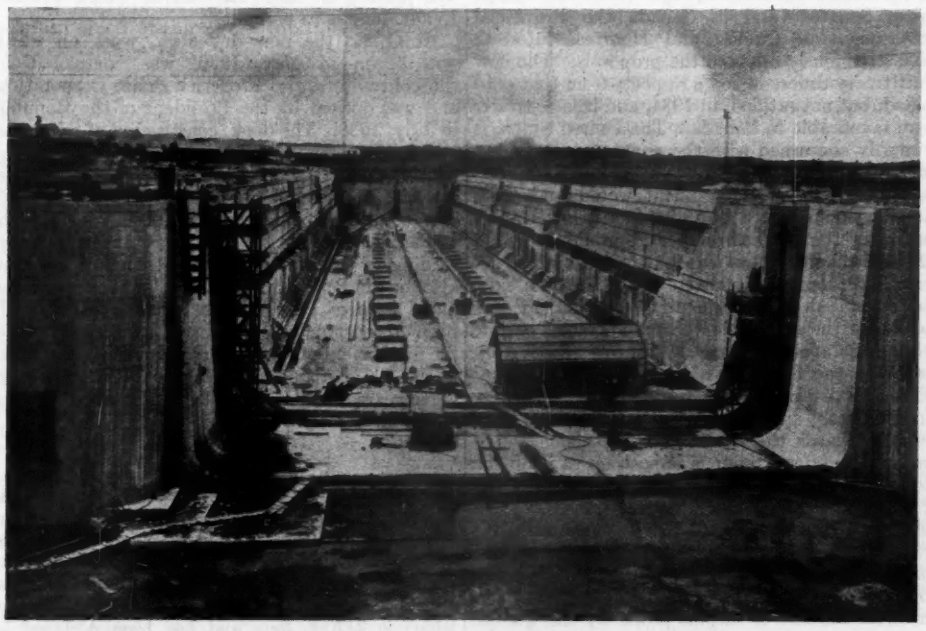
ON July 18th Sir Andrew Caldecott, the Governor of Ceylon, opened a new dry dock at Colombo, which has been constructed at a cost of £110,000. It has been built at the inner end of the old dry dock and has an effective length of 350ft., with a width of 87ft., and a depth over the cill at high water of 22ft. Work on the new dock was begun in August, 1935. The new section of the dock is closed by a "Box" type flap gate. It is reported that proposals have been approved for the construction in Colombo Harbour during the next two years of an oil dock, a deep-water quay, and other works at a cost of approximately £1,000,000.

Singapore

The Singapore naval base was officially inaugurated by the Governor of the Straits Settlements, Sir Shenton Thomas, on February 14th, 1938, by the opening of the new dry dock, now named the King George VI Dock, which is built to take any ship in the present British Fleet and is large enough to take ships of the greater tonnage now under discussion which may be built in the future. The new dock has an internal length of 1000ft., its entrance has a clear width of 130ft., and a depth over the cill of 35ft. at low water. It is closed by a sliding caisson. The contractors for it, as well as for most of the other constructional work carried out at the naval base since 1928, are Sir John Jackson, Ltd., of Westminster. Besides the dry dock, the contractors have constructed upwards of 6000 lineal feet of mass concrete wharf walls, which have an average height of about 70ft., and have carried out much excavation and reclamation work. Most of the berths alongside the quay walls have a depth of water of 40ft. at low water. Some idea of the scale of the works carried out may be gathered from the following quantities:—Excavation, 10½ million cubic yards; concrete, 900,000 cubic yards; dredging, 5¼ million cubic yards; reinforced concrete piling, 180,000 lineal feet; and cement, 140,000 tons. We published a short description of the works at the naval base in our issue of February 18th, 1938. The total capital expenditure on the base, on Naval Votes, will, when the dockyard is in full operation, have been about £11,000,000. Considerable sums have been spent, in addition, on fortifications and providing facilities for adequate air defence.

In 1922 the site of the naval base on the southern shore of the Johore Strait was jungle, malarial swamp, and rubber plantations. It has now been transformed into a healthy modern dockyard, covering some 2500 acres, with workshops, power stations, store houses, hospitals, and living quarters. Some parts of the structural work in connection with the naval base are still incomplete, but the main works were finished early in last year. Among the supplemental works included in the Votes for the Singapore base in the 1938 Estimates (£800,000) are additional store sheds, shore accommodation for officers and men from ships lying at Singapore for refit, and an extension of the wharf walls to provide additional berthing accommodation. The Civil Engineer-in-Chief at the Admiralty at the time when the works were designed and commenced was Sir Leopold Savile. The construction works were completed under his successors, Mr. T. B. Hunter and Mr. Athol Anderson, the present Civil Engineer-in-Chief.

Sir Shenton Thomas also performed on July 28th the opening ceremony in connection with the wharf extension which has been made at Kepple Harbour, Singapore. This work, now completed, provides the commercial port with a range of continuous berthing aggregating 2½ miles in length. The extension of 3316ft. westward from the end of the old west wharf has cost approximately £565,000. The quay wall is of concrete block work, and has a low-water depth in the berths alongside of 33ft. Transit sheds and godowns have been built and dredging and other subsidiary works have been carried out as part of the extensions, for which Messrs. Coode, Wilson, Mitchell and Vaughan-Lee, of Westminster, have been responsible as consulting engineers. The contractors for the new wharf are Topham, Jones and Railton, Ltd., who began the work in 1934.



KING GEORGE VI DRY DOCK AT THE SINGAPORE NAVAL BASE

Manila

It was reported in July that constructional work had begun on the extension to the northward of Manila Harbour. The new harbour works are to be made on a reclaimed area between the mouth of the Pasig River and Estero de Bitas, Tondo, and will take about three years to carry out.

The Yangtse Bar

The work of dredging a channel through the Fairy Flats of the sea bar at the mouth of the Yangtse River was begun in July, 1935, by the powerful drag suction dredger "Chien-She," built in Germany for the Whangpoo Conservancy Board. Dr. Herbert Chatley, now the consulting engineer to the Board, has stated that since September, 1935, when regular dredging operations commenced, up to the outbreak of hostilities between Japan and China, about 10,000,000 cubic yards of *in situ* material had been removed. Very little accretion had occurred in the cut, and there was, early in 1938, a depth of 22ft. at lowest low water over a part of the bar 3 miles in extent, where formerly there was no more than 18ft. The record daily output had been about 38,000 cubic yards of *in situ* spoil. A second, and more powerful dredger is now being built in Germany for the Conservancy Board, and is expected to be delivered early this year. The two dredgers will have a joint annual output of some 10,000,000 cubic yards of *in situ* material. We do not know what is the present situation of the dredging operations; if the disturbed state of affairs at Shanghai has resulted in a suspension of the work, the stability of the cut already made will be jeopardised.

AMERICA

Federal Expenditure on Public Works

The lavish expenditure of the Federal Government of the United States on public works continues to be criticised by financial and other interests from the point of view of absence of economic basis for many of the projects. At meetings of the American Society of Civil Engineers this aspect of some of the vast projects undertaken at the behest of the President has been stressed. It is alleged that works have been undertaken principally as a spectacular means of giving employment, without due consideration to their economics and of their usefulness or benefit when completed. Original estimates have been exceeded, in some cases doubled. Much of this criticism has been launched against the establishment by the Federal Government of hydro-electric power stations, many of them combined with the improvement of rivers for navigation, from which no adequate financial return can be expected. In the case of the Florida Ship Canal, work on which was begun over three years ago, the estimates are said to have been increased from £23,000,000 to £60,000,000, and work has now been halted by the refusal of Congress to appropriate further funds. There is said to be but little economic justification for this canal work.

Among other projects that have met adverse criticism are the Tennessee Valley dams, linked up with navigation improvements, and the improvement of the channel of the Upper Mississippi to afford a minimum depth of 9ft. at low stage.

The Tennessee Valley Project

The dams now being built in connection with the Tennessee Valley project are primarily designed for the improvement of navigation, and are provided with navigation locks of large capacity. The lock at the Pickwick Landing dam (see p. 30, *ante*), 207 miles above the mouth of the Tennessee River, begun in 1935, has a chamber width of 110ft., and an available length of 600ft. This lock will have a maximum lift of 60ft. The Guntersville dam, now nearing completion and situated 349 miles above the mouth of the river, has a lock with lift of 43ft., chamber width of 60ft., and a length of 360ft. A second lock of the same chamber dimensions as that at the Pickwick Landing has been planned, but will not be built until the requirements of traffic warrant it. The Chickamauga dam, begun in 1936, has a lock with a lift of 51ft., and of similar dimensions to that at Guntersville with provision for the addition of a larger lock at a later date. The largest dam on the Tennessee River, that proposed to be constructed at Gilbertsville, in Kentucky, 25 miles above the river mouth, has not yet been begun. The estimated cost of this dam is 112 million dollars. The increasing criticism of the Tennessee Valley Authority will probably have the effect of a temporary postponement of the construction of this work. We published an illustrated account of the works now being carried out by the T.V.A. in our issues of April 8th and 15th, 1938.

The Chesapeake and Delaware Canal

The ship canal between the Delaware River and Chesapeake Bay, which the Government of the United States has constructed under the Emergency Relief Appropriation Act of 1935, was completed, excepting extensions which are to be made to the existing jetties at the Delaware Bay entrance and some part of the deepening of the channel, early in the year. The original canal, connecting the two great sea inlets of Delaware Bay and Chesapeake Bay, was made between 1824 and 1829, and was a locked navigation for barges and other small craft. In 1919 the canal was purchased by the Federal Government, and between that year and 1927 was reconstructed as a sea-level canal at a cost of 13 million dollars. It then had a depth of 12ft. at mean low water and a bottom width of 90ft. The 1935 project, now realised, provided for a ship canal of 27ft. depth with a bottom width of 250ft. in the land cutting, about

15 miles, and of 400ft. in the approach channels. This enlargement involved the dredging of approximately 35 million cubic yards of material in the land section alone; one of the suction dredgers employed, the "Baltimore," built specially for the work at a cost of a million dollars, is one of the most powerful pipe-line dredgers afloat.

New York Harbour Channels

The deepening and widening of the ship channels giving entrance to the harbour of New York, which for many years have been proceeding under the control of the Corps of Engineers, U.S. Army, for the Federal Government, still continues. The authorised project for the channels in Lower Bay and Upper Bay, which was revised in 1937, has not yet been completely realised; but in the principal entrance channel—the Ambrose Channel, with its extension, the Anchorage Channel—there is now a depth of 45ft. at mean low water over a width which varies from 500ft. to 2000ft. This depth is now being dredged to the full intended width of 2000ft. throughout a total channel length of about 12½ miles.

San Diego, California

The harbour of San Diego, in California, is the most southerly port on the Pacific coast of the United States; it is land-locked and practically the whole of its artificial development has taken place since 1912. The Harbour Commissioners have expended since that year 5½ million dollars on port works and the expenditure of the Federal Government on dredging during the same period has been nearly as much. Further dredging and reclamation to be carried out by the Federal Authority are estimated to cost over 4 million dollars, in addition to expenditure by the Navy Department. The Harbour Commissioners have built, and are building, cargo piers and wharves on a large scale and there are extensive naval and military establishments in the port.

Panama Canal

It is reported that the Federal Government of the United States has under consideration the problem of the enlargement of the Panama Canal. Two alternative projects are being examined. One is to enlarge the Panama Canal by the construction of additional locks and improvement of the waterway at a cost of 200 million dollars. The other is the construction of a second and independent canal in Nicaragua, which is estimated to cost 722 million dollars.

Proposed Lake Champlain Waterway

The International Joint Commission appointed by the Governments of the United States and Canada to inquire into the question of a proposed deep-water canal between Montreal and New York City, reported early in the year that the construction of such a canal is not economically justified. Of the five alternative routes studied, the most practicable would be that from the St. Lawrence River, *viâ* the Richelieu River at Sorel in Quebec, to Lake Champlain, and thence by way of the present canal to the Hudson River at Albany. The cost of a 27ft. deep waterway by this route was estimated to be 342 million dollars.

Missouri River

The completion of the great hydraulic fill dam at Fort Peck, on the Missouri River, will be delayed by a recent accident, which unfortunately was attended by loss of life. The dam is about two miles long and will contain when completed more than 100 million cubic yards of fill. Recently and without warning a section of the upstream face, about 2000ft. in length and nearly 100ft. deep, slipped down into the water. At the time of the slide the work of construction was nearing completion.

The St. Lawrence Navigation

A year ago we referred to the report of the Board, appointed by the Minister of Marine of the Dominion Government, to inquire into the cause of the low water conditions in the navigable channel of the St. Lawrence River. As a result of the report of that Board a new low-water datum for the river was fixed, which is 2ft. lower than that established in 1897. The Canadian Government, also as a result of the report, placed a contract for the dredging of the navigable channel of the river, between Montreal and Quebec, to 35ft. depth below the new datum at a cost of £2,300,000. Considerable progress has been made with this dredging, but the full depth of 35ft. has not yet been secured throughout the whole of the channel.

The St. Lawrence Waterway Project

The State Department of the Government of the United States, in May, 1938, sent to the Government of Canada the draft of another proposed treaty to set up a Joint Commission to plan the development of the international sections of the Great Lakes and St. Lawrence waterway system. The tentative proposal involves the construction of a navigation canal, 27ft. in depth, between the St. Lawrence River at Montreal and the Great Lakes, combined with water power development. The construction of regulation works to control the levels of the Great Lakes would also be within the province of the proposed Commission. President Roosevelt during his visit to Canada in October, took the opportunity afforded by a speech at the opening of the Ivy Lea international bridge by the Canadian Prime Minister, Mr. Mackenzie King, and himself, to raise once more the question of the waterway.

We have frequently referred in these pages to the project known as the St. Lawrence waterway, which seems likely to provoke acute controversy both in the United States and in Canada. Both the Federal Government of the United States and the Dominion Government of Canada appear to favour the project; the earlier treaty negotiated by the United States with the Bennett Government a few years ago received widespread public support in both countries. The treaty, however, failed to secure the two-thirds majority necessary for its ratification when it came before the United States Senate; and in Canada the Provincial Government of Quebec and Montreal interests have strenuously opposed the proposals. The new draft treaty differs in some respects from that concluded, but not ratified, in 1934, and it is generally more favourable to Canada. The United States is primarily concerned with the power aspects of the project. Under the arrangement now proposed the United States Government would undertake the development of the International Rapids section of the St. Lawrence and would complete all the proposed works, except power-house structures and power equipment on the Canadian side. The estimated cost of the American share of this portion of the scheme is about £54,000,000, while the cost to Canada of completing the power developments on the Canadian side of the international section is estimated to be about £20,000,000. Unfortunately, the Provincial Government of Ontario regards the project with suspicion and is prepared to offer strenuous opposition to it on the grounds that, since Ontario already has a supply of power in excess of her immediate needs, such a large expenditure on further development is unjustifiable. The Provincial Government of Quebec is bent on preventing any additional power developments in Ontario which would interfere with the sale of surplus power by the Quebec Corporation. Montreal trading interests, moreover, object to a project which would open up navigation from Montreal to the Great Lakes to ocean-going shipping of large tonnage with a consequent reduction in the trade of the port of Montreal.

Under the terms of the proposed treaty the Government of Canada would undertake, not later than six years after the beginning of the construction of the Canadian works, to provide for the deepening of the channel of the Welland Canal to 27ft. and for the completion of some other essential links in the purely Canadian sections of the waterway, the cost of which is estimated to be about £7,500,000. The present depth of the Welland Canal is 25ft., but provision was made when it was constructed for the ultimate deepening of the channel to 30ft. and all the locks were made with this depth of water over the cills.

Canadian National Harbours Board

The chairman of the National Harbours Board of Canada, Mr. Ralph Campney, in an address delivered at Vancouver in May last, claimed, with apparent justification, that the new system of national control of the harbours of Canada, set up by the Act of the Federal Parliament in 1936, had been completely successful. He pointed out that the Act had its genesis in the recommendations made by Sir Alexander Gibb in the report on Canadian harbours made by him some years previously. Since the National Board came into being three properties have been added to those originally placed under the unified control. They are the Port of Churchill on Hudson's Bay, the grain elevator at Prescott, Ontario, and that at Port Colborne at the Lake Erie entrance to the Welland Canal. The original ports are Halifax, Saint John, Quebec, Three Rivers, Montreal, Chicoutini, and Vancouver.

In 1937, 80,000 vessels arrived at and departed from the ports under the Board's jurisdiction and 32 million tons of cargo were handled. The income of the seven original ports increased and the operating expenses decreased between 1935 and 1937 to such an extent, said Mr. Campney, that the taxpayers of Canada had, in 1937, 1,500,000 dollars less to pay in respect of harbour operation than they had to find in 1935.

Venezuela

Tenders have been invited for carrying out improvement works at the port of La Guaira. The work includes the extension of the existing north breakwater by about 500 m., the construction of a west breakwater 600 m. long, wharfage aggregating 1120 m. in length, reclamation work, and the dredging of the harbour to 10 m. depth.

Peru

A contract was placed by the Peruvian Government early in the year with the Frederick Snare Corporation, an American company, for the construction of a new harbour at Matarani, which is intended to be the future Pacific terminus of the Southern Railway of Peru. The cost of these works is estimated to be about £800,000. Two breakwaters, 2000ft. and 500ft. long, respectively, will protect an inner harbour in which a wharf 1500ft. long is to be built.

At Callao the new dry dock, work on which was begun in May, 1936, was completed by the contractors, the Frederick Snare Corporation, and was opened by the President of the Republic in July, 1938. The dock, constructed of reinforced concrete, has a usable length of 636ft., and a width of 79ft. at the entrance. The depth over the cill at mean high-water is 26ft. The dock has cost approximately £300,000, and will be available not only for the largest class of liners trading to the West Coast of South America, but also for the Peruvian Navy. Callao is the principal naval base of Peru and the arsenal has recently been reconstructed and extended. A contract for further extensions of the port works at Callao, at a cost of about £300,000, to be completed in three years, has also been placed with the Frederick Snare Corporation.

Trinidad

The deep-water harbour works at Port of Spain in Trinidad, to which we referred a year ago, are nearing completion. The works have been carried out by Edmund Nuttall and Co., Ltd., as contractors under the direction of Messrs. Coode, Wilson, Mitchell and Vaughan-Lee. The new wharf is 3170ft. long and has been designed to permit an ultimate depth alongside of 32ft. below low water, although 30ft. depth only is being provided in the first instance. The approach channel has been dredged to a depth of 30ft. at low water over a length of 13,000ft., and a width of 350ft. Hitherto ocean-going vessels have been obliged to anchor 2 to 3 miles from the shore; it will now be practicable for them to discharge and take in cargo at the wharf.

AUSTRALIA

Sydney

The Commonwealth Government announced early in December important additions to the Australian defence programme. An Admiralty engineer will be invited to Australia to advise on the most suitable site for a naval dry dock and repair shops at Sydney. The estimated cost of the works is £3,000,000, and it is intended that the dry dock shall be large enough to take in a capital ship.

Mackay Harbour

The harbour extension scheme now being carried out by the Mackay Harbour Board (Queensland) includes the formation of a harbour of 140 acres in extent protected by two breakwaters of rubble mound construction, one 4350ft. in length and the other 3375ft. The enclosed area is to be dredged and the berths alongside the quays will have 33ft. depth at low water of spring tides and 54ft. at high water. The first instalment of wharfage is to be provided by constructing a pier 766ft. long and 138ft. wide. The whole scheme is

estimated to cost £1,000,000. The breakwaters are being built by departmental labour and a contract for the pier has been let for £239,000.

Geelong

The Geelong Harbour Trustees (Victoria) have brought into use a new entrance channel, 29ft. deep at low water, which has been dredged since 1934 through Corio Bay at a cost of £106,000. The use of the new channel will avoid the necessity of large ships completing loading at Williamstown after leaving Geelong.

Electrical Engineering in 1938

No. III

(Continued from page 66, January 13th)

Electric Railways

Early in July, the Southern Railway electrification was advanced a stage further when electrified services between London, Littlehampton, and Bognor Regis were brought into operation. The coastal line from West Worthing to Havant and the branch line from Three Bridges were also electrified, and on those lines new services were put into operation. At an approximate cost of £2,775,000, the new scheme involved the electrification of 75 route miles. On Friday, December 30th of last year, the arrival of the first electric train at Reading marked a further step in the extension of the electrified system of the Southern Railway Company. The newly electrified lines from Virginia Water to Reading, *viâ* Ascot, from Ascot to Ash Vale and Brookwood, and from Aldershot to Guildford, add 43 route miles to the total of electrified track, making that total 655 miles and the track mileage 1644.

Two other important railway electrification schemes were put into service during the year. The first was the L.M.S. Wirral Line, on which through electric services are now being run between Liverpool Central, New Brighton, and West Kirby. The nineteen new three-car trains supplied for this electrification were all equipped by the B.T.H. Company, which also supplied the sub-station D.C. switchgear, high-speed breakers, and their control panels, and service transformers. The new trains run in conjunction with the original Mersey Railway trains (now modernised) over the section from Birkenhead North to Liverpool Central. The other scheme is the South Tyneside electrified lines of the L. and N.E. Railway. This is an extension of one of the earliest electrified railways in the country. Electrical equipment, comprising motors and control gear supplied by the B.T.H. Company some seventeen years ago, was modified to bring it up to date, and was put into service again under more arduous conditions. The B.T.H. Company also supplied all the transformers, mercury arc rectifiers, and associated D.C. control apparatus for the sub-stations. Work is proceeding on the Liverpool Street-Shenfield line of the L. and N.E. Railway.

Work on the electrification of the Central Railway of Brazil, the Metropolitan-Vickers Electrical Company reports, continued satisfactorily throughout the year. Sections were opened for traffic progressively as completed. The first order for fifty-two Metadyne control train units from the London Passenger Transport Board was followed during the year by two further orders, totalling seventy-three equipments, now in the course of manufacture. A description of the Metadyne control system will be found in our issue of November 11th. The order from the South African Railways for forty-two additional electric locomotives received in 1937 will be practically completed during the present year. Twenty-seven of these locomotives were despatched up to October 31st, and ten during November and December. The total number of locomotives ordered by the South African Railways is now 162.

The company received an order from the London and North-Eastern Railway for the complete electrical equipments for seventy main line mixed traffic locomotives in connection with the electrification of the Manchester, Sheffield, and Wath lines.

Work on these equipments is well advanced and deliveries will begin during 1939. The mechanical parts will be manufactured by the London and North-Eastern Railway Company at its Doncaster works, where the Metropolitan-Vickers Company will erect the electrical equipment and complete the locomotives. Each of these locomotives, having a total one-hour rating of 1850 H.P., will weigh about 84 tons, and will work at 1500 volts D.C. The maximum speed of the locomotives is to be 65 m.p.h. Each locomotive is designed to draw a 250-ton passenger train up a gradient of 1 in 125 at 53 m.p.h., a 500-ton express goods train up a similar gradient at 40 m.p.h., and a 700-ton goods train up a similar gradient at 26 m.p.h. They are to be equipped for regenerative working, which will be very valuable when handling the heavy goods trains down the long gradients in the Pennines. Additional motor coach equipments for the suburban electrification near Sydney, Australia, were ordered by the New South Wales Government Railways.

During the year the New Zealand Government Railways opened the Wellington and Paekakariki and the Wellington and Johnsonville electrified 1500 D.C. lines in the North Island. For the Paekakariki line the equipment supplied by the English Electric Company comprised one complete electric locomotive and also the electrical equipments, steel sections, axle-boxes, plates, &c., for seven locomotives, which are being assembled in the railway workshops in New Zealand. Each locomotive is equipped with four motors, having a total one-hour rating of 1240 H.P. and is designed for a maximum service speed of 55 m.p.h.

For the Johnsonville line the equipment supplied by the English Electric Company comprised six two-coach units, each of 660 H.P. The maximum service speed is 55 m.p.h. For railway electrification at home, the English Electric Company has in hand a contract from the London, Midland and Scottish Railway for the re-equipping of the Liverpool and Southport electrified lines. Orders continue to be received from the Southern Railway in connection with the exclusive running contract for traction equipments which the English Electric Company holds.

Post Office Work

The estimated value of contracts placed by the Post Office for engineering plant was £12,500,000, representing increases of 19 and 98 per cent. over the values for the years 1937 and 1936, respectively. All the contracts were placed with British firms. The total value of material not of British manufacture was only £3000, or 0·024 per cent. of the total.

Newly designed hand-microphone subscribers' instruments having greatly reduced side tone were introduced and standardised. In one model the telephone and bell set are separate fittings, and in the other they form a combined unit. Accommodation is provided in the body of this instrument for a maximum of three key sets which are used when the unit forms part of an installation requiring signalling facilities between stations.

To meet the special facilities required by the telephone order departments of large stores, &c., an order table equipment was designed. The arrangements provide for cyclic distribution of calls over the order clerks' positions, the number of clerks in attendance being adjusted to the load. Three types are available, one for ten lines, another for up to 100 lines, whilst the third type, which is suitable for bankers, brokers, &c., has a capacity of ten lines ancillaried over the units. The two last types provide for immediate access by all operators to all lines.

Great progress has been made towards the mechanisation of the telephone service. During the twelve months ending September, 1938, 393 automatic exchanges were opened. No fewer than 346 were of the smaller or "unit" variety. The progress made in the conversion of small manual exchanges to automatic working was considerable. Over 2000 unit automatic exchanges have been opened since the general introduction of the scheme in 1929. The range of modern equipment available for unattended automatic exchanges was extended by the development of a new type which is designed for use in areas where the subscribers' development is between 200 and 800 lines. The equipment is assembled from a number of standard units, which are built from standard automatic exchange apparatus and incorporate the latest features in design.

With the progress of mechanisation the problem of satisfactory transmission of dial impulses over long junction and trunk circuits has required solution. Dialling by ordinary D.C. is satisfactory over short distances where a metallic loop is available. For long trunk circuits which include valve repeaters, means of dialling by the use of A.C. in the audio-frequency range have been made available. This method, however, involves expensive equipment which cannot be justified for circuits of intermediate length, and as this class of circuit is usually of too high a resistance for normal D.C. methods, it will be equipped with a new type of apparatus which includes an electro-mechanical device which will accept dialling impulses which have been distorted through the previous transmission link and retransmit them with a minimum of distortion. When placed at convenient points in a chain of circuits, the apparatus makes possible the dialling over longer distances than would otherwise be the case. By means of this and other associated developments subscribers will be able to dial their own connections, up to a 15-mile radius, without the intervention of an operator. Special equipment has also been designed to meter the appropriate call fees. For longer distances up to 100 miles, a long-distance D.C. system has been developed and is now in operation on the operator-dialling circuits between Belfast and Ballymena.

To meet the cases which arise when telephone service is needed at short notice, *i.e.*, for special events or to augment or substitute the existing service, an experimental small mobile automatic

HAND-MICROPHONE TELEPHONE INSTRUMENT

exchange was built. Mounted on a trailer, this unit type exchange will cater for nearly 100 subscribers' lines. It is complete with its own power plant, and the secondary cells will be charged by either a petrol-driven generator or by a rectifier set where public A.C. supply mains are available. The exchange will be hauled to the required site, where it will be necessary only to connect up to the external lines.

The twelve-circuit carrier system, which was first introduced in 1936, has proved so successful that the main long-trunk network of this country is being planned chiefly on this basis. The existing and projected routes now cover 1700 miles. The twelve-circuit carrier system uses the frequency range of 12–60 kilocycles, whilst the audio-plus-four carrier system employs the range 300–16,000 cycles. In recent submarine cables of coaxial form, but using paragutta as the dielectric, both of these carrier systems are employed on the same cable pairs to give a total of sixteen circuits. In the Belfast–Stranraer cables the twelve-circuit system is used complete on a four-wire basis, together with the lower four circuits of the audio-plus-four carrier system operating on a two-wire basis. In the Anglo-Dutch cables, however, the five channels of the audio-plus-four carrier system are used, together with the upper eleven circuits of the twelve-circuit carrier system, a four-wire basis being adopted for both systems. This latter arrangement has also been adopted for the new Anglo-Eire cables recently laid between Nevin and Howth.

Experiments are now in hand to increase the number of circuits in submarine cables by the use of higher frequencies, obtained by group modulation of one or more twelve-circuit groups. Where it is necessary to overcome the greater attenuation of the cables at the higher frequencies, common high-power amplifiers will be used at the sending

end. Experiments have also been made to ascertain the practicability of providing music channels on the twelve-circuit carrier cables. With normal cables it is necessary to provide special screened pairs for music transmission, but with the new cables it was found possible to equip the carrier pairs so that music may be transmitted in the frequency band below that occupied by the carrier system, *i.e.*, below 12 kilocycles.

The coaxial cable between London and Birmingham has been extended to Manchester and is being further extended to Leeds and Newcastle. One super-group of forty circuits is now working between London and Birmingham, whilst installation of another group is in hand. On tests the circuits were found to be quiet, the articulation good, and cross talk and babble absent. As a stringent test of the stability of the circuits, seven circuits were connected in series to form a single circuit 800 miles long, the speech in each path thus undergoing forty-two modulation processes. The performance of this composite circuit was good and only slightly inferior to that of a normal London-Birmingham coaxial circuit. Even with this extended circuit echo was not noticeable. The transmission time between the two ends of the overall circuit was less than 5 milliseconds. The slight degradation present was obviously due to the six intervening points at which modulation and demodulation occurred, the majority of which would not be present in a commercial circuit of that length. The installation of two super-groups (eighty circuits) between London and Manchester is now proceeding.

Novel methods of power supply have been adopted for some of the repeater stations. The power is fed out along the coaxial conductors from an adjacent repeater station and filtered from the high-frequency signals. At Northampton repeater station special methods have been introduced to safeguard the coaxial service in case of failure of public supply mains. Should a failure occur, a standby oil-driven engine is started and drives a synchronous motor generator and fly-wheel which was previously running from the mains supply. The novelty of the installation is that the A.C. motor operates as an alternator from the instant the supply fails and thereby provides an A.C. supply to the coaxial equipment without interruption to the service. When the supply from the mains is restored the engine automatically shuts down and the motor generator again takes power from the mains.

The principle of the negative feed-back amplifier, which, owing to its large inherent degree of stability, has brought the twelve-circuit carrier and coaxial systems into the realm of practical telecommunication engineering, is to be used in the design of all future repeater and amplifier equipment. New amplifiers, giving increased line stability, have already been designed and should reduce the cost of maintenance to a large degree.

Equipment has been developed for the application of the compressor-expander principle (hitherto restricted to long radio links) to trunk cable circuits on which the normal ratio of signal to noise cannot be obtained. This system consists of two separate units, the compressor at the sending end of the trunk line and the expander at the receiving end. The compressor is an amplifier which gives greater amplification to weak signals than to strong signals, so that at the output of the compressor the range of level is more uniform than at the input. At the receiving end the expander (which is an amplifier arranged to amplify loud signals more than weak signals) restores the original range of levels in the speech. By this process the weaker syllables of speech, which are more vulnerable in transit, are sent through the cable at a higher level of power than would normally be the case. As a result the signal-to-noise ratio at the receiving end is improved.

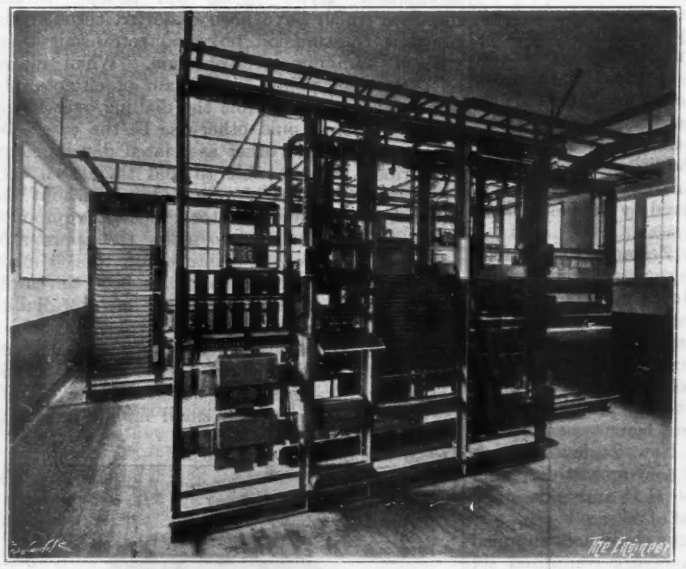
Experiments conducted during the year make it possible definitely to envisage the provision of fully automatic switching conditions over the whole of the inland telegraph network. The present network is composed mainly of eighteen-channel (voice-frequency) systems, and the teleprinter is the standard telegraph instrument. Since teleprinter signals of 20 milliseconds duration are at present being transmitted over this network there is no difficulty in transmitting a Strowger impulse of 33 milliseconds duration. With the aid of a dial the operator at any office can therefore cause a two-motion selector to seek a wanted route, either directly to a nearby office or to a switching centre, and by successive dialling can set up a circuit to any other office over a number of intervening links. Transmission of the telegram directly from office of origin to office of delivery is then possible without retransmission at an intermediate point. The advantages of such a scheme are obvious. The transmitting time from office to office is reduced and the necessity for retransmission is avoided. The scheme would give a quicker telegram service at reduced operating costs. An offset to this gain, however, would be the cost of the switching equipment and additional line plant channels required. The experimental equipment, consisting of twenty-two teleprinter positions and associated auto-switching equipment, was subjected to both artificial and "live" traffic with very satisfactory results, and an investigation of the costs having shown that appreciable savings can accrue from the use of the system, details of a scheme to convert the Birmingham telegraph zone are now being considered.

Several facilities have been developed for use in this proposed system. Other tests made have shown that eighteen-channel voice-frequency telegraph equipment can be operated over individual channels of the twelve-circuit carrier telephone systems with entirely satisfactory results. One cable pair can therefore be made to carry 216 teleprinter channels, capable of transmitting a total of 14,400 words per minute.

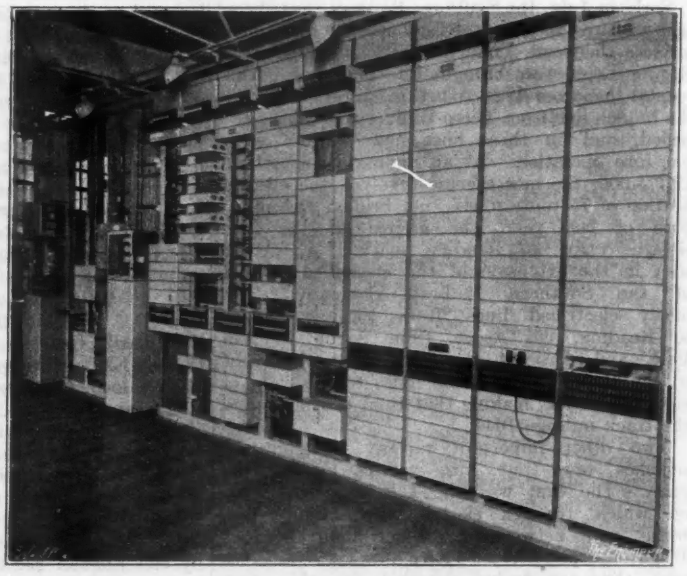
The amount of radio-telegraph and radio-telephone traffic has increased greatly in the past few years. The level reached in 1938 was approximately double that in 1936. A single-sideband short-wave receiver operating on a reduced carrier transmission was installed at Baldock radio station for the Transatlantic telephone service. Successful trials were made of passing, simultaneously, two conversations over one receiver, and, during the period of heavy traffic caused by the crisis in September, an extra channel to New York was provided by this means. The extended use of this method, which uses both upper and lower sidebands, should double the number of short-wave channels without causing any interference to other radio services. A new transmitter at Rugby, which has a peak radio-frequency power of 60–70 kW, also uses this method.

A "constant-volume" amplifier for use on incoming radio-telephone circuits has been developed to counteract "fading" effects. The output volume from this device is substantially constant, irrespective of changes in the input level, so that variations in speech volume which would otherwise be passed on to the telephone subscriber are reduced to small proportions.

Sunspot activity and magnetic disturbances were more prominent in 1938 than in previous



UNIT TELEPHONE EXCHANGE



CO-AXIAL CABLE TERMINAL REPEATER STATION

LEADING IN CABLES FOR NEW TRANSATLANTIC RADIO STATION

years, and a maximum sunspot activity is expected to occur in the years 1939–40–41 with a resulting increase in the number and duration of interruptions on the short-wave long-distance radio services.

To combat this condition as far as the Transatlantic telephone service is concerned, a new receiving station is being provided to make use of an improved system of reception, developed by the Bell laboratories. The station is situated at Cooling Marshes, near Rochester, Kent, and the receiving system to be used discriminates between signals arriving at different downcoming angles. In this way it is hoped to avoid the confusion which occurs normally when signals travelling by different paths arrive "out of step." A similar and complementary station is being provided in the United States by the American Telephone and Telegraph Company.

At the Wick coast station, a system of remote receiving aerials connected by coaxial cable to a specially screened operating room at the station has made it possible to pass messages to and from ships by means of radio-telephony without shutting down the radio-telegraph equipment.

The progressive policy of the Post Office of utilising ultra-short-wave radio links as alternatives to submarine cables was well maintained. A new service between the mainland and St. Mary's, Isles of Scilly, was opened in January. Two circuits are employed, one for telephony and the other for teleprinter working during the day and telephony after 7 p.m. The radio apparatus, which is normally unattended, is giving entire satisfaction. Sites for further ultra-short-wave radio stations have been obtained for some of the Scottish Isles and also for the English Channel.

The East Perth Power Station

THE Western Australian Government electricity supply scheme was officially opened in 1913 by the Hon. J. Scadden, C.M.G., who was then Premier. When the tramways scheme was acquired by the Government a larger power station was necessary. Later, an agreement was made with the Perth City Council to take a bulk supply, and by this arrangement the Government became the generating authority.

In 1916 the Tramways and Electric Lighting Board of Fremantle entered into an agreement to take a bulk supply, and the municipalities of Midland Junction and Guildford also entered into such an agreement. Later, the Government began direct distribution to consumers in Bassendean, Greenmount, Upper Swan, Kalamunda, South Guildford, Queen's Park, Kenwick, Maddington Gosnells, Kelmscott, and Armadale. The districts of Cottesloe Beach, Cottesloe, and Peppermint Grove were taken over in 1924. At present the Government activities extend over approximately 300 square miles.

For supplying the City of Perth, the Government tramways and the outer suburban area, there is a 6000-volt underground cable system. Power is supplied to the City of Perth at 6000 volts, three-phase, 40 cycles, at four points, known as "ring main sub-stations." The Government tramways are supplied from a sub-station at the western end of the city through which the ring main cables pass.

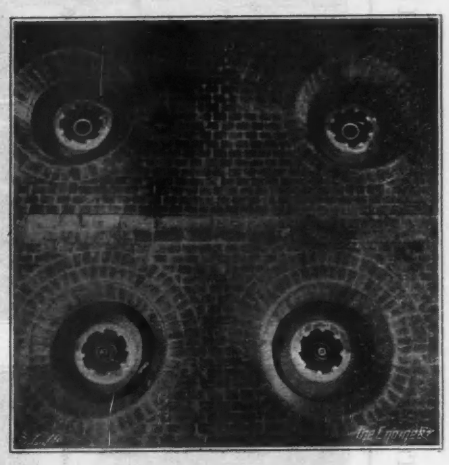
The 20,000-volt transmission system is composed of overhead lines carried on jarrah wood poles. In all cases the lines are divided into sections of approximately 5 miles, and wherever possible there are sub-stations at the dividing points. All the line conductors are spaced at 3ft. centres vertically and 4ft. horizontally. The line is designed to limit the drop of pressure to 5 per cent. at the full rating of the conductors.

The "A" generating station contains five low-pressure reaction turbines, giving a total output of 32,000 kW. The turbines are coupled to three-phase, 40-cycle generators feeding the station bus-bars at 6300 volts. For transmission to the outer areas, the pressure is increased to 20,000 volts. The steam conditions are :—Boiler pressure, 210 lb. per square inch ; steam temperature at turbine, 600 deg. Fah. Mechanical stokers are fitted to the boilers, which have a total evaporation of 290,000 lb. of water per hour.

In 1934, when extensions became necessary, it was decided that the most economical plan was to build alongside the existing "A" station. The new building is a steel-framed structure with reinforced concrete walls, floors, and flat roof over the entire structure. Ample natural lighting is provided, wherever possible, by windows extending the full height of the building. The site was piled to carry the structure, and a total of 710 piles were driven 30ft. The loading was fixed at 20 tons per pile. The concrete foundations were reinforced to deal with the heavy concentrated loads, such as main stanchions, turbo-alternator, &c. As the fuel used is of a relatively low calorific value with high moisture content and costing 21s. 6d. per ton at the power station, it was essential to design the new station with a high thermal efficiency consistent with capital expenditure considerations.

After careful considerations it was decided that the boilers should be fired with pulverised Collie coal and that the steam pressure to the turbines should be 600 lb. per square inch, delivered at a temperature of 800 deg. Fah. The boiler plant consists of three Lopulco tridrum units operating at a pressure of 625 lb. per square inch and a temperature of 850 deg. Fah. Each boiler is capable of evaporating 100,000 lb. to 135,000 lb. per hour, it being assumed that two boiler units would be in operation to drive the new turbo-alternator when operating at maximum load. The maximum electrical demand in 1934 was 21,000 kW. It was decided to install one two-cylinder turbo-generator having an output of 25,000 kW at 2400 r.p.m. As it was essential that the new high-pressure boilers should be able to supply steam to the A station in the event of an emergency, provision has been made to connect the high-pressure header in A station to the low-pressure header in B station, the steam being de-superheated and reduced in pressure to suit the turbo-alternators existing in A station. The generator main switchgear follows that generally used in the A station, but is of larger capacity. The oil circuit breaker is a semi-ironclad unit, having a rupturing capacity of 500,000 kVA.

The boiler plant is capable of supplying 400,000 lb. of steam per hour from three units, each having a normal duty of 100,000 lb. per hour with a maximum rating of 135,000 lb. per hour. The boilers are Lopulco bent tube units, having an integral water cooled furnace with fin tube walls. Fitted to the front wall of each furnace are four Lopulco "R" burners for burning pulverised Collie coal. All the drums are solid forged. Drums have an inside diameter of 4ft. The thickness of the walls varies between $2\frac{7}{16}$in. to $3\frac{3}{8}$in. The weight

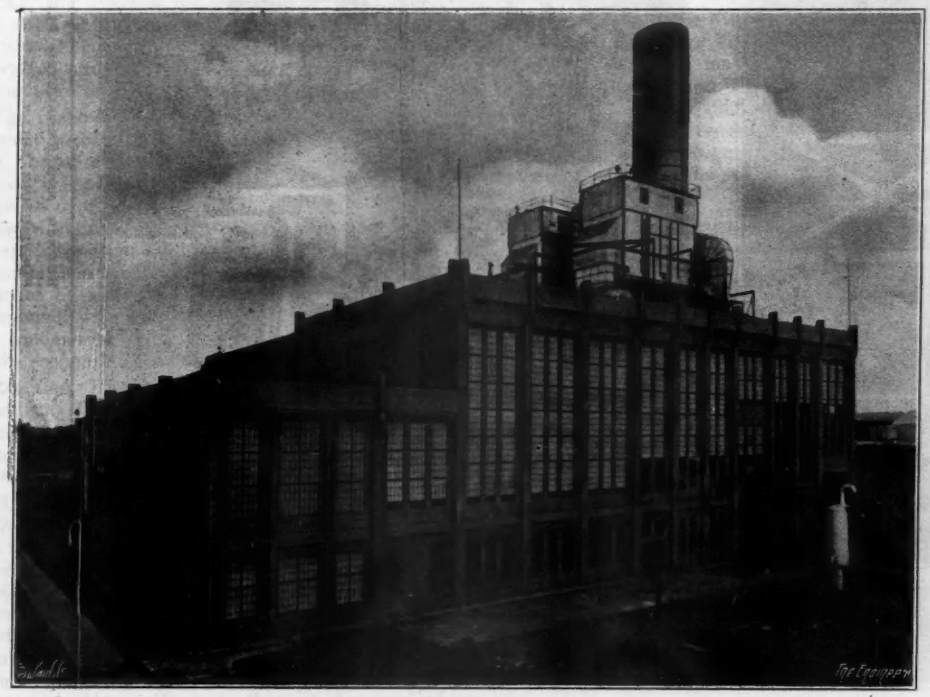


PULVERISED COAL BURNERS

of the rear drum is 21·5 tons. Complete with its furnace, each unit is lined with refractory brick backed by insulating bricks and finally covered by metal casings $\frac{1}{16}$in. thick. Each boiler unit has a total evaporative surface of 11,100 square feet.

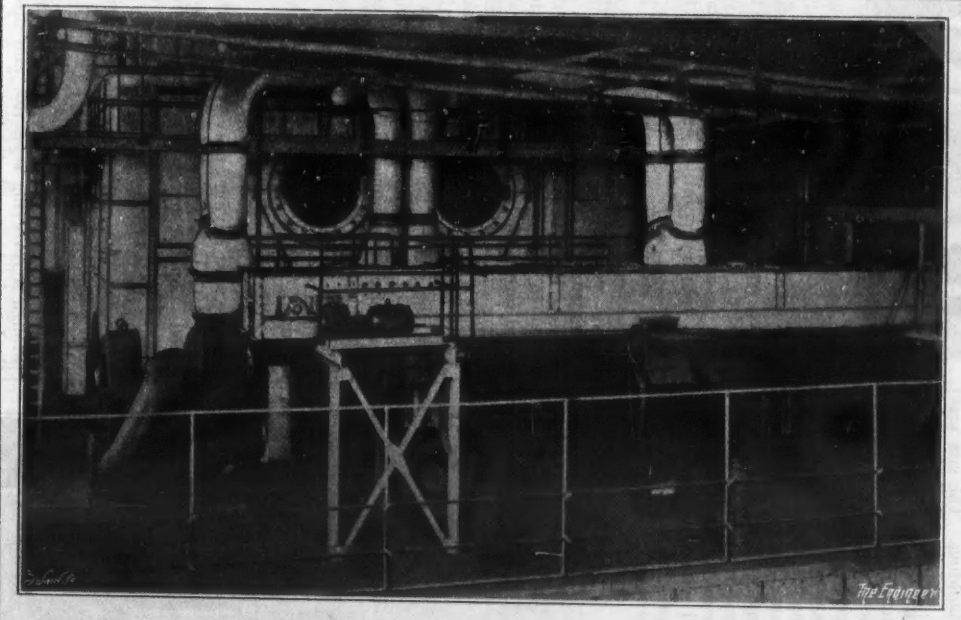
The steam is superheated in a M.L.S. superheater having external and automatic control equipment to maintain the steam temperature at 815 deg. Fah. plus or minus 15 deg. Fah. between loads of 75,000 lb. and 135,000 lb. per hour. Constructed with patented forged return bends and spherical joints, the total heating surface is 5000 square feet. Each boiler unit has a Heenan twin steel tube economiser with shrunk cast iron fins to extract the maximum heat from the gases. Each economiser has a heating surface of 2340 square feet in forty-eight tubes. To ensure maximum efficiency and satisfactory combustion in the furnace an "Isco" plate air heater is fitted to each boiler with the plates arranged so that a contra-flow of gas and air is obtained. Each heater consists of 145 elements, 17ft. 6in. long with a total heating surface of 22,837 square feet.

Collie coal having an average calorific value of 8769 B.Th.U. per pound is supplied to medium-speed Lopulco mills, which grind it by contact between a revolving table and rollers that idle on the table. Whilst each boiler is fitted with two mills, each mill is capable of producing sufficient pulverised coal to ensure that the boiler unit will evaporate 100,000 lb. per hour. After it is ground the coal is drawn by an exhauster fan through a revolving separator and discharged to the Lopulco burners in the front wall of the furnace. The speed of mills and exhausters is controlled by hydraulic couplings. To ensure that no dust will be discharged to the atmosphere, Lodge-Cotterell electrostatic precipitators are installed on the roof of the boiler-house. The precipitators are completely enclosed in steel casings and are designed

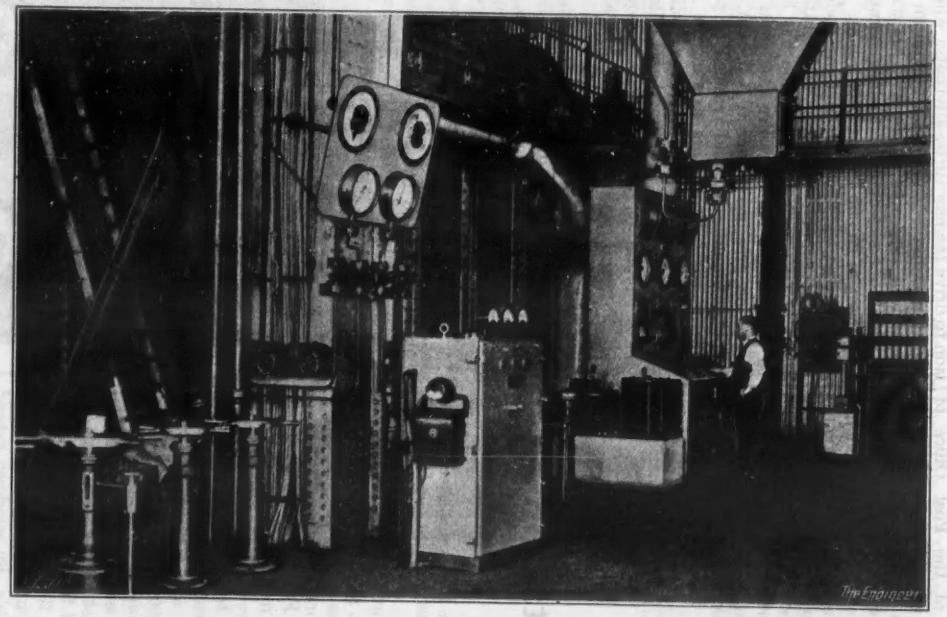


EAST PERTH POWER STATION

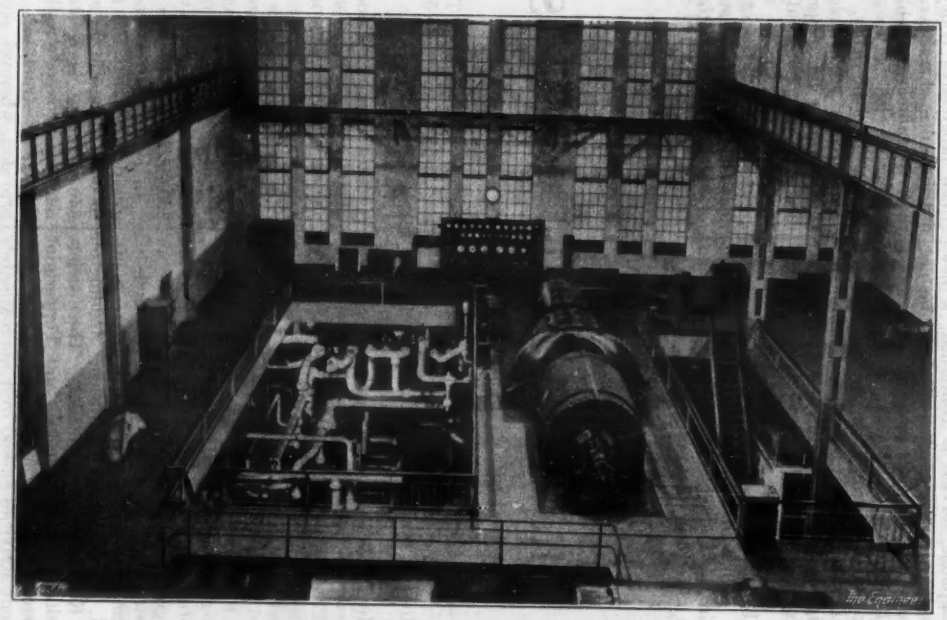
EXTENSIONS AT THE EAST PERTH POWER STATION, AUSTRALIA



BURNER AND EXHAUSTER FLOOR
PULVERISING MILLS



BOILER CONTROLS
TURBO-GENERATOR ROOM



for dust extraction of 95 per cent. when passing 75,000 cubic feet per minute.

After passing through the electrostatic precipitators the gases are handled by induced draught fan. One fan per boiler discharges to a single stack for serving four boilers. Each induced draught fan is a high-efficiency single-inlet unit operating at a maximum speed of 565 r.p.m. For supplying combustion air to the furnaces there are two fans for each boiler unit. The variable-speed drive for both induced and forced draught fans is obtained through hydraulic couplings. The self-supporting steel stack is in the centre of the boiler-house roof. It is capable of passing gases from the three boilers and a fourth unit for which space is available in the new boiler-house. The stack is constructed of copper bearing steel, 23ft. 3in. inside diameter and rises to a height of 110ft. above the boiler-house roof. To ensure perfectly clean units, soot blowers are fitted to boiler furnaces and economisers.

All steam feed and blow-down piping was supplied by Aitons. The high-pressure steam and feed-water piping has Corwell welded joints. To take care of expansion in the pipe lines, corrugated pipes and creased bends are used and flexible hangers are installed for all supports. All valves used for high-pressure work are by Hopkinsons, Ltd. There are three boiler feed pumps, two electrically driven and one steam driven. Each pump has a capacity of 300,000 lb. of water per hour, operating against a total pressure of 825 lb. per square inch. Vulcan-Sinclair couplings, giving a speed range of 2300 r.p.m. to 1980 r.p.m., are used for controlling the electrically driven pumps.

For supplying the steam to the turbines in A station reducing valves and a desuperheater have been provided. This equipment is automatically controlled and is capable of passing 200,000 lb. to 250,000 lb. of steam per hour, reducing the pressure from 625 lb. per square inch to 225 lb. per square inch, and the temperature from 850 deg. to 700 deg. Fah. All instruments for the satisfactory operation of the boiler-house equipment are fitted to individual panels arranged on the boiler operating floor.

Coal is delivered to the station by railway and discharged into a storage bunker beside the boiler-house. From the bunker it is conveyed by means of tray conveyors to elevators which discharge the coal into a 600-ton bunker in the A station. This bunker acts as additional storage capacity and is utilised by B station which has no coal storage in the boiler-house itself. Coal from the 600-ton bunker is delivered to the pulverising mills in B station by totally enclosed conveyors running the full length of the boiler-house of A station. Between the conveyors and the mills, weighers are fitted to record the exact amount of coal delivered to the high-pressure boiler plant. All ash from the combustion chambers, from the soot hoppers, and the electrostatic precipitators, is delivered into concrete troughs built into the floor of the boiler-house and traversing the full length of A station, finally discharging ash and water to a swirl pit. From the swirl pit the ash and water are pumped to a reinforced concrete bunker where the ash is deposited and the water drawn off and returned to the head of the water sluice.

The turbo-alternator consists of a two-cylinder tandem turbine driving a three-phase alternator and exciter at a normal running speed of 2400 r.p.m. The maximum rating is 25,000 kW. Expansion of the steam takes place in the high-pressure cylinder from the 600 lb. pressure down to approximately 50 lb. absolute pressure. The steam is then led to the single-ended, low-pressure cylinder by a single pipe below the engine-room floor level, where it is further expanded down to the condenser vacuum of 28·28in. Hg. (baro. 30) at the economical load of 20,000 kW.

Reaction blading is used throughout both cylinders. There are altogether sixty-eight moving rows, varying in height from 1¼in. with a mean diameter of 21¼in., to 15in. with a mean diameter of 60in. The high-pressure cylinder contains forty-nine rows, all "end-tightened."

The steam chest is mounted alongside the turbine and is connected to the cylinder by flexible corrugated U pipes, a construction which eliminates the possibility of any strains being put on the turbine cylinder. In accordance with Parsons' usual practice, the high-pressure spindle is bored through from end to end, and every portion of the interior surface was carefully examined by means of a "borescope" to make sure that no flaws exist in the metal. Three-stage feed heating is employed, giving a final condensate temperature of 324 deg. Fah. at the economical load.

The totally enclosed, three-phase, 40 cycle, 6300 volt, 2400 r.p.m. turbo-alternator has a continuous maximum rating of 31,250 kVA. Excitation is supplied from a direct coupled exciter. The stator is built up of electrically welded mild steel plates and bars, which ensure a rigid construction with the minimum weight. To ensure uniform magnetic flux distribution, the laminated core stampings are divided into segments and assembled with staggered joints.

Parsons patented stranded type of coreless cable, with the individual wires insulated and spiralled in a definite lay to eliminate eddy currents, is used for the core conductors.

A single solid forging of high-grade mild steel forms the rotor, which has windings composed of copper strip and embedded in radial slots distributed round the periphery.

In the multiple inlet enclosed ventilating system the air is circulated by two motor-driven fans. Cool air admitted over the whole length of the stator ensures uniform and effective cooling of all parts of the alternator. The exciters and slip rings are totally enclosed and are ventilated by air drawn from the main air circuit, thereby protecting them from dust and dirt in the atmosphere. The cooling air is returned to the main air circuit through viscous type air filters which remove any carbon or metallic dust from the carbon brushes or the commutator and slip-rings. A direct-coupled exciter provides the excitation for the alternator field, while a self-excited auxiliary exciter provides excitation for the main exciter field.

The surface condensing plant consists of a 33,000 square feet condenser, steam-jet-operated air ejector, and duplicate condensate extraction pumps. The shell of the condenser is of welded steel with water boxes of cast iron.

The supply to the auxiliary equipment, comprising in general the boiler-house and turbine fans, pumps, and ash-handling plant is at 440 volts, three-phase, 50 periods.

Four station transformers, each of 1000 kVA capacity, supply a twenty-four panel Metrovick metalclad switchboard with 2000 amperes air-insulated bus-bars, through 1500 amperes electrically operated oil circuit breakers. This switchboard feeds through the remainder of the oil circuit breakers, the largest unit fan and pump motors, and a thirty-three-unit Metrovick "unit auxiliary" switchboard. The latter is arranged in sub-divided groups linked by bus-section coupler units, each group dealing with the boiler-house requirements for such services as induced and forced-draught fans, pulverisers, and exhausters.

Complete control of the whole of the metalclad switchgear is effected from a miniature control board. A mimic diagram, brought into relief by small pigmy lamps behind panel slots, shows the state of all major circuits of the metalclad switchboards, and also the position of the contacts of each large motor starter. Totally enclosed fan-cooled motors are provided for the pulverising mills, exhausters, induced and forced draught fans. The starting gear for these is enclosed in a dust-tight sheet steel cubicle. The auto-transformers and contactor gear contained in this cubicle are operated from the control board in the station control room. Drip-proof fan-cooled 500 H.P. motors drive the feed pumps. A control cubicle for these motors, similar to the one described, is operated from the control board in the station control room. Engine-room telegraphs and loudspeaking telephones for the turbine and the boiler-house have also been supplied.

On page 86 we give illustrations of the Lopulco mills, the burner and exhauster floor, the boiler controls, and the new turbine room.

The main contractors were: International Combustion, Ltd.; English Steel Corporation, Ltd.; Superheater Co., Ltd.; Hopkinsons, Ltd.; Dewrance and Co., Ltd.; Senior Economisers; Metropolitan-Vickers Electrical Company, Ltd.; Lea Recorder Co., Ltd.; Herbert G. Richardson and Co., Ltd.; Davidson and Co., Ltd.; Hydraulic Coupling and Engineering Company, Ltd.; Lodge-Cottrell, Ltd.; Ivor Power Speciality Company, Ltd.; Wallsend Howden; Stothert and Pitt, Ltd.; Gwynnes Pumps, Ltd.; Glenfield and Kennedy, Ltd.; Wm. Beardmore and Co., Ltd.; Geo. Kent and Co., Ltd.; Mather and Platt, Ltd.; Vickers-Armstrongs, Ltd.; C. A. Parsons and Co., Ltd.

Oil-Engined Rail Traction in 1938

No. III

(*Continued from page 53, January 13th*)

France

AT the beginning of 1938 the French National Railways had a total of 662 railcars in service and 140 on order. In addition, there were 260 railcars on private and departmental railways, making a total of nearly 1100 vehicles in service or on order in France. Of the National Railways' vehicles, nearly 500 were fitted with oil engines. Monsieur Victor Nicolet, of the National Railways, believes that the system may ultimately possess 1500 railcars, covering more than 185,000 miles a day. At the beginning of 1938 mileage by railcars on the National Railways represented 23½ per cent. of the passenger train mileage and 12¼ per cent. of the total train mileage. The proportion of the total mileage covered by railcars increased during the first ten months of the year. There is also a noticeable tendency to increase the power of these vehicles, many of the newest cars being of 500–600 H.P. Some of the fast business railcar services in France have recently been withdrawn, but this economy is part of the general policy of making the railways pay, for 2700 miles of line have been closed and steam services also have been cut down, and in many cases replaced by railcars.

The largest units so far constructed are the 4000 B.H.P. locomotives for the P.L.M. section, which were described in our review article last year. One of these locomotives is fitted with two Sulzer 2200 H.P. engines; the other with four

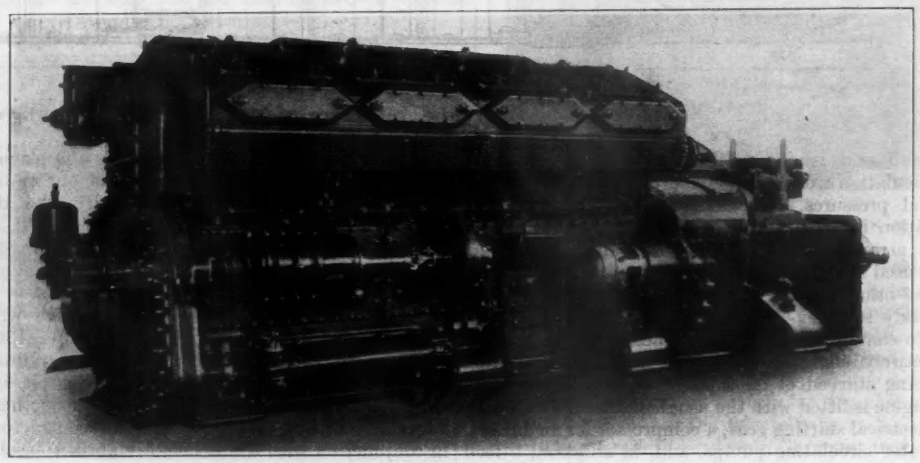


FIG. 27—500 H.P. OIL ENGINE FOR RAILCARS—RENAULT

M.A.N. engines, developing a maximum of 1050 B.H.P. In each case Rateau turbo-chargers are fitted, and the operating engine speed is 700 r.p.m.

A recently developed power unit for railcar work is illustrated in the accompanying engraving, Fig. 27. This engine, manufactured by the Renault concern at Billancourt, represents one of the latest types used on the French National Railways. It has sixteen cylinders, arranged in two inclined banks, with bores and strokes of 156 mm. and 180 mm., and a normal rated output of 500 H.P. at 1500 r.p.m. A solid and direct injection system, together with the four-stroke cycle, has been adopted. Many refinements are to be found

Five of an order for ten Renault 500 B.H.P. railcars with mechanical transmission, fitted with the above-described engines, have been delivered to the French National Railways, and an order for seventeen 600 B.H.P. cars, in which two 300 B.H.P. twelve-cylinder engines are installed, are in course of delivery.

Switzerland

In the Supplement to our issue of a fortnight ago, January 6th, 1939, there was illustrated the new 4400 H.P. oil-electric locomotive for the Roumanian State Railways on its trials. Another view of this locomotive is reproduced on page 94

and erection of the electrical parts and individual axle drives, as well as the supercharging sets for the oil engines. The design and supervision of work on the whole locomotive and the building of the oil engines and accessories were in the hands of Sulzer Brothers, Ltd.

During the past year Sulzer Brothers delivered or had under construction many types of vehicle, but we have no space available for their detailed description. Apart from the contract referred to

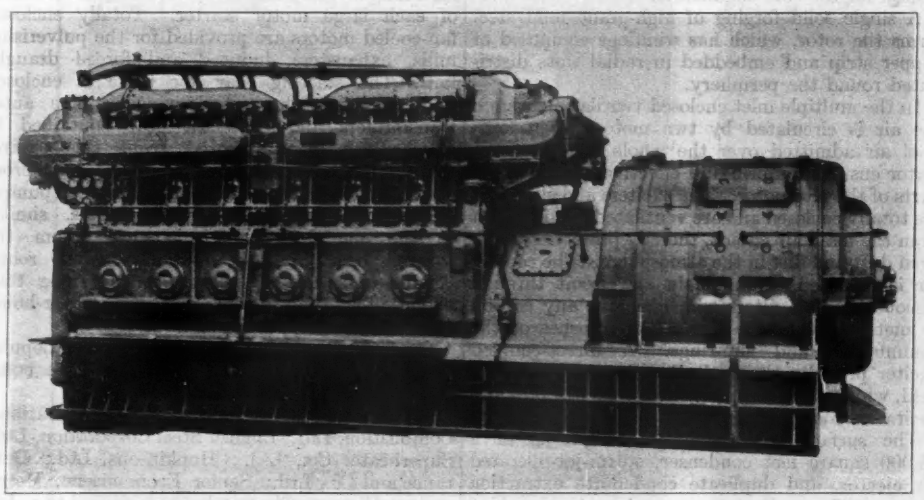


FIG. 28—2200 B.H.P. OIL ENGINE AND GENERATOR FOR ROUMANIA—SULZER

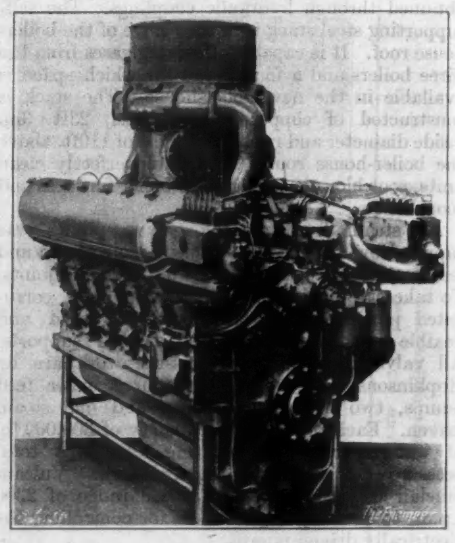


FIG. 30—12 CYLINDER 600 B.H.P. ENGINE—MAYBACH

above, in course of delivery were three shunting locomotives of 600 B.H.P. each, for the French National Railways, constructed by the French Marine et d'Homécourt concern, and two locomotives of 735 H.P. each for the Cie. des Phosphates de Constantine. The last-mentioned vehicles are to haul mineral trains of 500 tons on a metre-gauge line from Kouif to Oved Keberit. The Sulzer oil engines were built in the St. Denis works of the Marine et d'Homécourt, which also constructed the vehicles. Engines for two 1200 B.H.P. locomotives for the Swiss Federal Railways are under construction in Messrs. Sulzer's Winterthur works. Several other smaller orders were completed.

In many countries the advantages of pressure

in the design. The chromium-nickel-molybdenum steel crankshaft is carried in nine bearings, and it is drilled through the crank pins and the main bearings for lightness. Each pair of pistons is connected to a common crank pin by a connecting rod and a master connecting-rod. The big-ends of the connecting-rods are fitted with hardened steel bearings, which can be readily replaced, without removing the parts from the engine, access being gained through large doors in the crank case. Each cylinder head is fitted with four valves, two inlet, and two exhaust, and the design is stated to have a high volumetric efficiency, together with small and readily cooled valves, a good water circulation around the injector and low temperatures and pressures. Needless to state, forced lubrication is fitted throughout; a double oil circuit is arranged, whereby automatically one circuit is used for supplying oil to the working parts while the other is employed in filtering and cooling oil ready for use. By means of a valve the circuits are changed over. It is claimed that this method entirely eliminates the possibility of the engine being starved of oil through choked filters. The engine is fitted with the usual auxiliaries, including electrical starting gear, a compressor for air brakes, water circulating pumps, and, in addition, a feed pump for filling the fuel tanks on the railcar and a centrifuge for cleaning the lubricating oil.

in Fig. 39. In view of the very full description which appeared in THE ENGINEER of May 20th, 1938, only the main features of the design will be mentioned. The locomotive is constructed in duplicate halves, each unit being fitted with a Sulzer 2200 B.H.P. twelve-cylinder oil engine with direct fuel injection and charging according to the Büchi system by means of Brown Boveri charging blowers. An important advantage of pressure charging was realised, inasmuch as a locomotive of this size and power could only be constructed to come within the loading gauge by the utilisation of a forced induction system. The principal feature of the engine—see Fig. 28—is the placing of two crankshafts in a common housing, forming a double row arrangement. The drive to the generator set is geared with a ratio of 1 : 1·2, so that the speed of the generator, corresponding to the maximum crankshaft speed of 700 r.p.m., is 840 r.p.m.

The Swiss trial runs of the locomotive were carried out between May 9th and June 15th. These tests aroused lively interest in railway circles and drew considerable attention at the time. The locomotive was built by Sulzer Brothers, Ltd., Winterthur, acting as general contractors, in conjunction with the Locomotivfabrik Henschel und Sohn, G.m.b.H., of Cassel, for the mechanical parts, and Brown Boveri, Baden, for the delivery

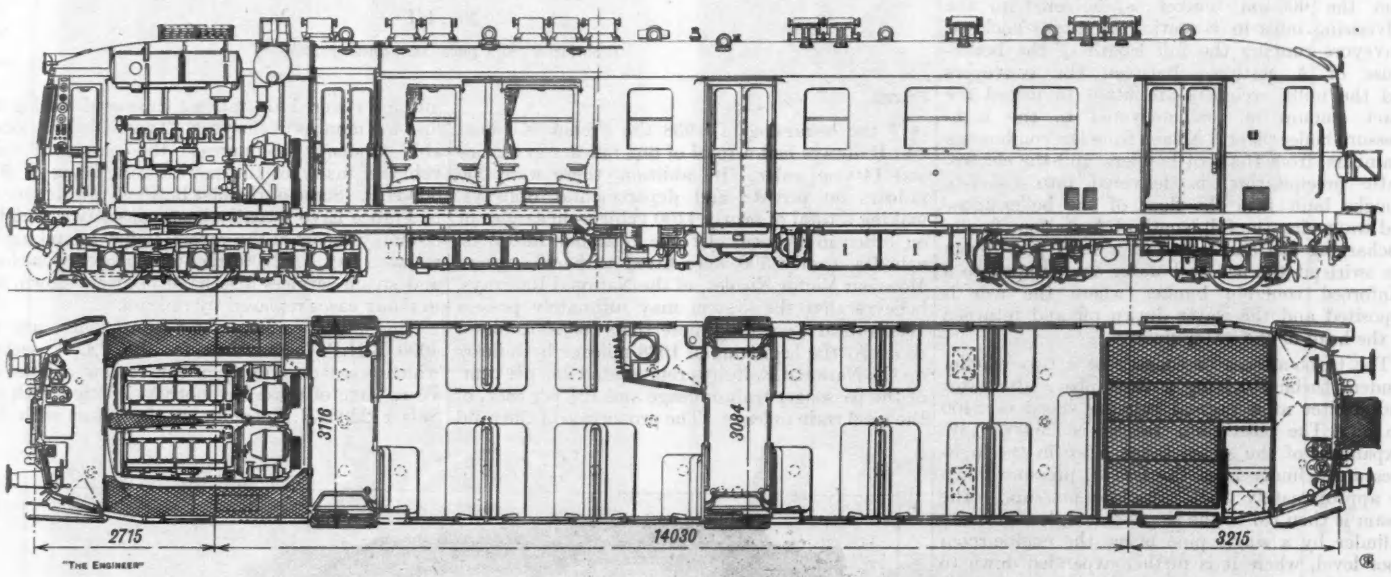


FIG. 29—500/550 B.H.P. OIL-ELECTRIC RAILCAR FOR DANISH STATE RAILWAYS—FRICHS

charging are being realised and applied to engines for rail traction purposes. The Büchi Syndicate, of Winterthur, is responsible for much of this type of work. We have already mentioned, in the first article of this series, the Wickham conversion power bogie, fitted with a Saurer engine, for use on high-altitude lines in South America, and, above, the 4400 B.H.P. locomotive for the Roumanian State Railways. In each of these cases a substantial increase in power is obtained, on the one hand, at high altitudes; on the other, at moderate altitudes, but at the same time gaining the advantage of compactness. The main feature of the Büchi system, of course, is that pressure charging is effected by means of exhaust gas driven blowers, thereby tapping a source of

waste power. The system is in wide use in Germany, in the new M.A.N. and Maybach-engined trains; in America, and in other countries.

Another Swiss firm, the S. A. Adolphe Saurer, of Arbon, has given attention to supercharging its oil engines. Its B X D type of oil engine in supercharged form has been manufactured in its works for many years, but during the past year its B L D and B Z D engines have also been turned out so equipped. Of the last-mentioned type, three units were supplied, and thirty engines are on order in the firm's works and with its licensees in various countries. Its licensees in Italy have on hand an order for 136 engines in all, some of which are to be supercharged. These engines are for the Italian State Railways, and are claimed to represent the biggest order for railcar engines ever placed.

Denmark

In Denmark during the past year A/S Frichs, of Aarhus, built and delivered several oil-engined shunting locomotives of 115–125 B.H.P.; oil-electric railcars of 250–275 B.H.P., and one 410–450 B.H.P. oil-electric locomotive, for use on various Scandinavian systems. Perhaps the most interesting order was that for ten 500–550 B.H.P. oil-electric railcars of the type designated by the firm as "Mo." The general arrangement of one of these vehicles can be seen in the drawing reproduced in Fig. 29 herewith. The cars follow the firm's standard practice, being fitted with two 250–275 B.H.P., six-cylinder oil engines, the output being developed at 1000 r.p.m. The weight in working order of the power railcars is 56 metric tons, and the maximum speed is 120 kiloms. per hour. Multiple-unit couplings are provided, so that the vehicles can be operated with trailers, or in rakes of three, with a trailer interposed between two power railcars.

The above-mentioned railcars are for service on the Danish State Railways. Two three-car trains of this description were placed in service some time ago on the express train route from Friedrichshafen to Padborg, from the northernmost terminal in Jutland to the German frontier—a distance of 444 kiloms. The firm states that the time for the journey for these vehicles is regularly 3½ hours shorter than that for the express steam trains on the same route.

In conjunction with its licensees, it is stated that the concern has now manufactured 215 oil-engined vehicles with a total of about 80,000 H.P., and that the distance covered by these vehicles has exceeded 60 million kiloms.

Germany

Oil-engined traction for all railway purposes is very highly developed in Germany, and during the year 1938 there was a large output of vehicles and engines from the major manufacturing concerns. As is perhaps to be expected in a country which was a pioneer in the application of this form of rail traction, progress has been such that a large measure of standardisation has been achieved. The Reichsbahn has put into service in the past few years a large number of passenger railcars and has demanded for reasons of interchangeability and economy that equipment shall be, as far as possible, standardised. As an example, there is now being manufactured a horizontally opposed arrangement of oil engine by four different concerns, to the same general design. Several of these makers' engines are illustrated and described below.

A firm which is one of Germany's largest builders of oil engines is Maybach-Motorenbau G.m.b.H., of Friedrichshafen. For rail vehicles three standard types of oil engine are constructed, consisting of a six-cylinder engine, developing 225–250 B.H.P. at 1450 r.p.m., a twelve-cylinder V arrangement, 1400 r.p.m. and 410–450 B.H.P., and the latest engine, which is a supercharged version of the 410 H.P. type, producing 600–650 B.H.P. These engines are notable for a low weight to power ratio, the figures being 5·8, 4·9, and 4·0 kilos. per horsepower respectively. In the engravings herewith, Figs. 30 and 31, are illustrated the supercharged 600 H.P. engine, with turbo-charging on the Büchi system, and a typical 600–650 B.H.P. power bogie, arranged for electric drive. Also illustrated, in Fig. 32, is a component used as a cooling unit.

During the past year the German Reichsbahn has given special attention to the development of railcar services. All the existing two-car express railcars are equipped with 410 H.P. Maybach engines, and the three-car trains which have been in service for two years on the Berlin and Breslau line have the firm's 600 H.P. engines. In view of the successful results obtained with these cars, fourteen more three-car 1200 H.P. trains, comprising two power cars and a trailer car interposed, have been placed in service. For these units, built by the Linke-Hofmann Works, Maybach supplied a total of twenty-eight supercharged 600 H.P. engines. The German Reichsbahn now has no less than thirty-two two-car and three-car units, for speeds of 150–160 kilom. per hour.

FIG. 31—600 B.H.P. POWER BOGIE—MAYBACH

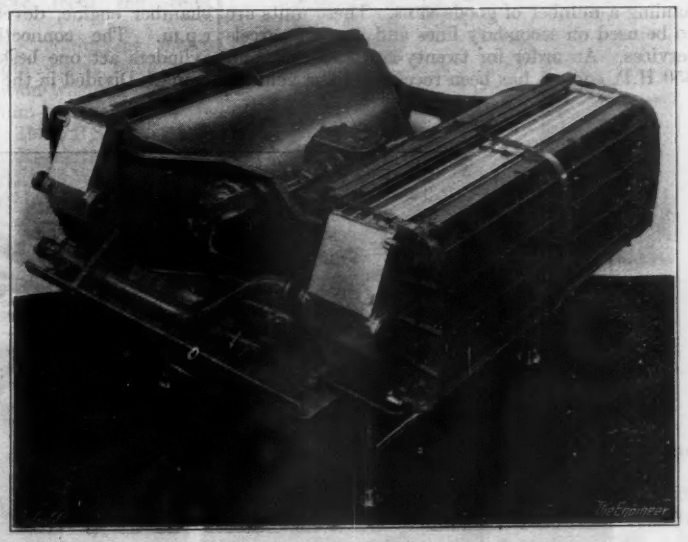


FIG. 32—COOLING UNIT—MAYBACH

In another district, the Ruhr industrial area, traffic has been developed similarly. The schedules are characterised by the short distances between stops, and up to the present time services have been run with eight-wheeled railcars, with Maybach engines. During the year eight two-car units were put into service, and now the whole "Ruhr-Schnellverkehr"—fast services in the Ruhr—is carried out exclusively with railcars equipped with Maybach engines. Forty 225 H.P. Maybach engines are being built for eight-wheeled single railcars for secondary services. These vehicles are intended for a speed of 80 kilom. per hour and the first units successfully underwent their trials recently. Like all railcars of the Reichsbahn, each can be coupled with two trailers equipped with remote control, or two such units, making a rake of two power cars, can be coupled together and controlled from any of the drivers' cabs.

In 1939 the railcar services in Germany are to be considerably extended. For fast traffic eight four-car trains are on order, each equipped with two

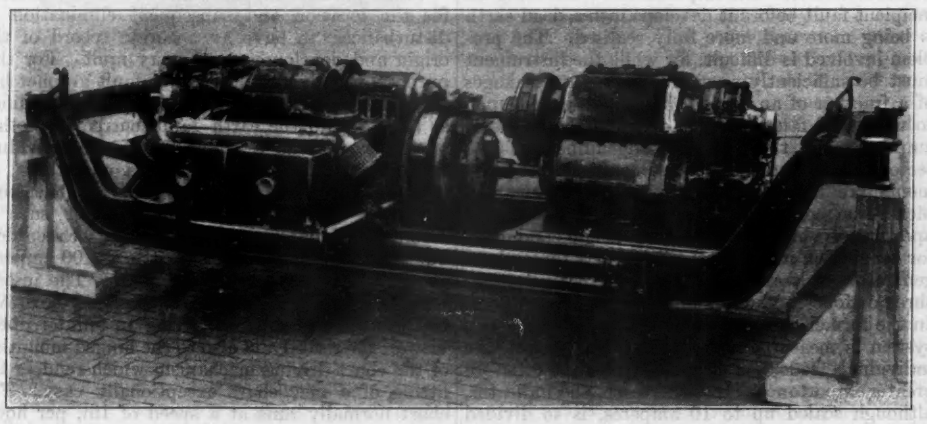


FIG. 33—180 B.H.P. HORIZONTALLY OPPOSED ENGINE—D.W.K.

FIG. 34—ENGINE ROOM OF 1350 H.P. TRAIN—M.A.N.

600 H.P. Maybach engines, to be mounted in the front and rear bogies. For fast traffic in mountainous regions, passenger single railcars of 600 H.P. each are to be placed in service. These vehicles have been under construction for some time, but very recently the programme was enlarged by an order for thirty more cars of the same type.

Goods traffic on the lines of the German Reichsbahn has been effected up to now nearly exclusively with steam trains. Encouraged by the successful results obtained with Maybach-engined goods railcars supplied in 1930, the Reichsbahn has decided to order railcar locomotives, which can themselves be loaded with goods and are capable of hauling a number of goods vans. These units are to be used on secondary lines and for fast parcels services. An order for twenty-two 450 H.P. and 650 H.P. engines has been received. The vehicles will attain speeds of 120 kilom. per hour, so that they can also be used for passenger working.

The firm has an order for export of twelve engines of the supercharged 600 H.P. type for the Belgian State Railways. These engines are to be installed in three-car express railcars, two in each unit. The vehicles are at present under construction at the works of La Brugeoise et Nicaise & Delcuve, of La Louvière, Belgium, and they will be put into service during the present year.

In Holland the Netherlands State Railways has given orders for twenty five-car trains, following on the successful results previously achieved. Eighteen of these trains will be equipped with Maybach engines, consisting of sixty-three 600 H.P. units. In Fig. 37 on page 94 is shown one of the original three-car trains, fitted with two 410 H.P. engines. These units were constructed by Werkspoor N.V., of Amsterdam.

Up to the end of 1938 the Maybach concern had supplied or had under construction about 800 oil engines, with a total of about 330,000 H.P., for use in railcars, and the aggregate distance covered in service was about 120 million kilometres.

In the accompanying engraving, Fig. 33, is shown a horizontally opposed eight-cylinder 180 B.H.P. oil engine manufactured by the Deutsche Werke Kiel A.G., of Kiel. It is one of a type being simultaneously built to Reichsbahn specification by the Daimler-Benz, D.W.K., Humbold-Deutz, and M.A.N. concerns. The engine is designed to develop its full rated output at a speed of 1500 r.p.m., and has cylinders with a bore of 128 mm. and a stroke of 180 mm. Fuel consumption is stated to be about 200 grammes per B.H.P.-hour at full load. In our engraving we show the engine mounted on a sub-frame coupled to one of the firm's latest designs of gear-box and mechanical transmissions, giving four speeds in either direction. An interesting feature of the controls is the use of compressed air for speed changing, the air being obtained from an auxiliary compressor which also supplies the braking system. Servo controls are arranged to operate multiplate friction clutches for taking up the drive.

One of the latest trains for the Reichsbahn is shown in an engraving, Fig. 38, on page 94. Designed as an experimental unit, it consists of four cars, with a single M.A.N. engine, developing a maximum output of 1400 H.P. at 700 r.p.m., mounted in the first car on the underframe. The main engine is supercharged on the Büchi system. Power for the auxiliaries is supplied by a 150 B.H.P. auxiliary engine. Directly coupled to the main engine is a D.C. generator, from which current is fed to four nose-suspended traction motors, two on each inner bogie of the end cars. In Fig. 34 herewith the engine and generator installation of one of these units is illustrated. Welded steel construction has been largely used, particularly for the power car, which has a massive welded framework, weighing about 7½ tons, for carrying the engines and generators. All the electrical equipment was supplied by the Mannheim works of Brown Boveri, but the train was designed and constructed at the works of Maschinenfabrik Augsburg-Nürnberg A.G.

In Fig. 35 is shown another product of the M.A.N. concern. It is a twelve-cylinder horizontally opposed compressorless four-stroke cycle antechamber engine, developing 275 B.H.P. at 1500 r.p.m. The connecting-rods of two opposing cylinders act one beside the other on a common crank. Divided in the vertical plane of the crankshaft, the crank case halves are cast integrally with the cylinder cooling jackets, into which are drawn cylinder liners. The two halves are held together by anchor bolts taking up the tensile stresses caused by combustion. This engine, mounted in its frame, is one of a type which can be interchanged with the engines and frames of similar output built by D.W.K., Daimler-Benz, and Deutz, as mentioned above.

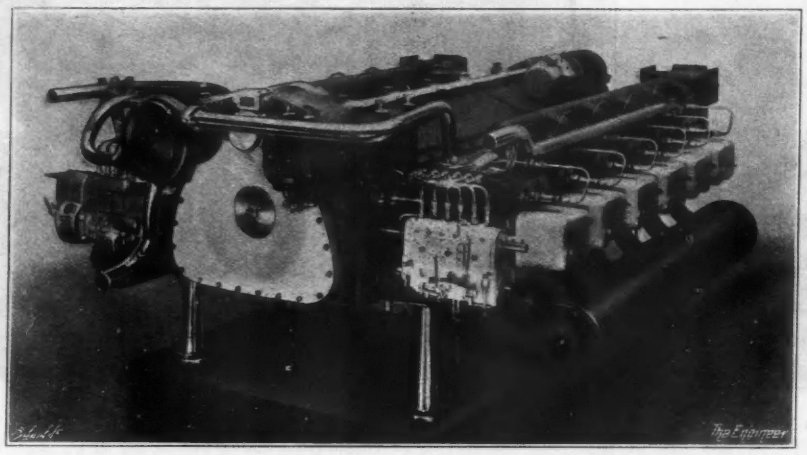


FIG. 35—275 B.H.P. HORIZONTALLY OPPOSED ENGINE—M.A.N.

Two interesting designs of oil engine for rail traction are manufactured by Deutz-Motoren-Gesellschaft, of Köln. Reference to one of these types has already been made. It is a twelve-cylinder *vis-à-vis* arrangement, with an output of 275 B.H.P. at 1500 r.p.m., designed to be interchangeable with the engines of the three other manufacturers listed above. In our review article last year we illustrated and described its chief features. An engine of this type was fitted in a railcar with mechanical drive, built by the German firm Gebr. Credé, Kassel-Niederzwehren, for a South American railway company, during the past year.

The second design utilises a horizontal arrangement, in this case with eight cylinders, the cylinders being arranged in line. A continuous rating for rail traction is given as 175 B.H.P. at 1600 r.p.m., and the bores and strokes are 130 mm. and 170 mm. respectively. Numerous railcars equipped with Deutz engines of up to 200 H.P. have been constructed recently by the Triebwagen-und Waggonfabrik Wismar (Mecklenburg) concern.

America

In the United States progress was steady and along the recognised lines for both passenger and goods traffic. As was mentioned in the introduction to this article, unsupercharged, two-stroke engines of 900–1200 H.P. are more or less standardised, the drive being invariably through an electric generator and traction motors. Long-distance oil-electric trains have been found profitable on many lines, and their number was increased during the year by the introduction of many new services. In view of the limited space at our disposal, it is impossible here to give a full account of the developments which took place, and only a single example of the passenger trains can be illustrated or described.

On page 94 (Fig. 36) we illustrate one of the latest passenger streamlined trains to be put into service. It is a four-car 1200 H.P. unit, running on the mid-western lines of the Chicago, Rock Island and Pacific Railroad. Known as Rock Island "Rockets," the fleet put into service by the company comprises two four-car trains and four three-car trains, running on five services, ranging in length from 161 to 489 miles. The average speeds on these runs range from 53 to 60 m.p.h. The trains are hauled by oil-electric streamlined locomotives of 1200 H.P. each, built by the Electro-Motive Corporation. The trains themselves were built by the Edward G. Budd Manufacturing Company. In each case the locomotive weighs 110 tons, and the weight of a three-car articulated train, including locomotive, is 250 tons. In the case of the four-car articulated unit the complete weight is 286 tons. In service the trains have proved to be profitable and are popular with the public.

As in the case of other western railways, the adoption of oil-engined trains on the Rock Island was the result of a careful study of ways of stemming the decline of passenger traffic and for recovering as much as possible of the large amount which had been diverted to other agencies of transportation. These studies directed to specific routes, led to the conclusion that the streamlined fast train, with its popular appeal, availability in service, and economy of operation, was capable of reversing the downward trend—a conclusion which has been justified by the service results.

The Physical Society's Exhibition

No. III

(*Continued from page 56, January 13th*)

SELF-PROTECTED earth leakage indicators and recorders were shown by Everett, Edgcumbe and Co., Ltd., of Colindale Works, Hendon, London, N.W.9. The importance of detecting an incipient fault before it develops into a dead earth is being more and more fully realised. The problem involved is difficult, for while the instrument must be sufficiently sensitive to indicate leakages of a fraction of an ampere it may be called upon to withstand fault currents of many thousands of amperes. In the Everett Edgcumbe self-protected leakage indicators these conflicting requirements are met by the provision of a saturable nickel-iron core transformer, through the central aperture of which passes either a single conductor, for connection in the earth circuit of a three-phase generator or transformer, or, alternatively, the three or four conductors of an individual feeder. In the former case, the earth leakage of the whole system is measured and in the latter that of the individual feeder or branch, which is often of greater importance. In either case, the indicator, although scaled up to 10 amperes, is so divided that small fractions of an ampere can be measured, and, at the same time, owing to the saturation characteristics of the core, the equipment is undamaged by the most severe fault.

Under modern supply conditions it is essential, for the location and subsequent elimination of disturbances, to have an accurate record of the origin and development of every fault. For this purpose, the Everett Edgcumbe fault grapher has been largely used, and has recently been modified so as to record the earth fault current, whether of the system as a whole or of an individual section or feeder, by means of a one, three, or four-conductor current transformer of the kind described. A recent requirement for such a recorder was that 20,000 amperes must be recorded, but that readings down to as little as 100 amperes should also be legible on the chart. The instrument is shown in Fig. 22. Attention may be drawn to the curved glass front, giving an uninterrupted view of the record and also to the hinged mounting of the chart driving mechanism which renders the fitting of a new chart exceptionally easy. The chart normally runs at a speed of 1in. per hour, but on the occurrence of a fault, this is instantly

increased to ½in. per second, and this speed is maintained so long as the fault persists.

The Everett Edgcumbe universal testing set shown in Fig. 23 has been developed specially to meet the requirements of garages and motor car service depôts. It enables electrical faults to be located and tests made on the various electrical devices of the modern car. It comprises a multi-range ammeter, for current measurements on the starting battery as well as on all accessories; a voltmeter, and an ohmeter, together with a high-tension calibrated spark gap for sparking-plug and

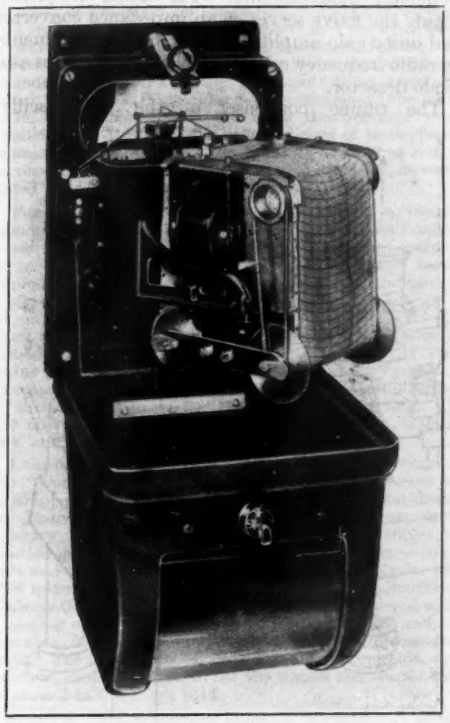


FIG. 22—EARTH LEAKAGE RECORDER—EVERETT

magneto testing. Measurements of the starter current can be made under actual working conditions and without any disturbance of the car wiring.

Another exhibit on this stand was a colliery winding cage speed recorder. Very stringent requirements regarding the braking and landing speed of winding cages are contained in the latest regulations, and all winding gear has now to be tested at least once a quarter. The Everett

FIG. 23—UNIVERSAL TESTING SET—EVERETT

Edgcumbe winding cage speed recorder has been developed to enable such tests to be made with ease. The circular chart is driven by a flexible shaft at a speed proportional to that of the winding drum, *i.e.*, of the cage itself. A pen traces a spiral line on the chart, and is so arranged as to indicate fractions of a second, the timing being effected by means of a synclock synchronous motor. In this way the speed of the cage at any point is not only clearly indicated, but is permanently recorded, To avoid any calculation a gauge of transparent celluloid forms part of the equipment, and by its means the speed in feet per minute at any point can be read direct.

A new low-range light tester (Fig. 24) was shown by Ferranti, Ltd., of Hollinwood, Lancashire. This supplements the firm's standard dual-range instrument of 0–25 and 0–250 candles. The new light tester is a three-range instrument permitting much lower readings to be obtained. The three ranges are 0–1, 0–10, and 0–100 foot-candles, with a scale length of approximately 4in., enabling light intensities in the neighbourhood of those employed in street lighting to be measured. The sensitive movement is operated by a bank of nine light cells housed in the instrument lid, which, when required, can be detached to enable the instrument to be used in a position remote from the cells, with leads about 6ft. long.

A 1500-volt D.C. testing equipment shown was one of two equipments which have been developed for use in connection with the pressure testing of low and medium-voltage cables in accordance with B.S.S. 480—1933, B.S.S. 7—1926, and the Electricity Supply Regulations of 1937. The equipment consists of a two-valve rectifier circuit with the positive output terminal earthed. It is suitable for operation on any 50-cycle, single-phase supply, between 200 and 250 volts, and is capable of giving 1500 volts for fifteen minutes

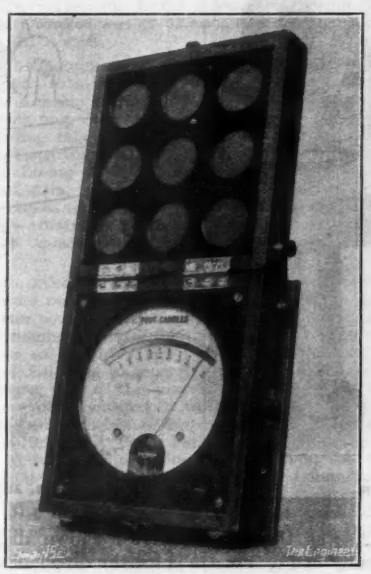


FIG. 24—LOW-RANGE LIGHT TESTER—FERRANTI

to the cables when laid and jointed. The valves are connected on the voltage doubler principle, and to ensure that the D.C. output is sufficiently smooth for testing purposes, smoothing condensers are included. To enable the voltage to be applied gradually to the cable under test, a moving coil regulator is incorporated. A voltmeter indicates the applied voltage, and a three-range milli-ammeter the leakage current.

Besides other electrical instruments, there were aircraft instruments, including an improved gyroscopically controlled bank and turn indicator and fuel and oil pressure gauges.

A 250-kV Van Der Graaf electrostatic generator (Fig. 25) was exhibited by Messrs. H. A. H. Boot and A. H. Knight, of the University of Birmingham, and the Birmingham Technical College, The generator consists of a hollow spherical electrode about 1ft. in diameter, supported on an insulating column 2ft. 6in. long. Within this column is an insulating belt about 3in. wide, running at about 4000ft. per minute. A surface charge is imparted to the belt by passing it between a fine wire brush and an insulated metal plate with a potential difference of about 5000 volts between them maintained by a magneto. The charge is carried up into the sphere, where it is removed by another wire brush. Whatever the potential of the sphere, the charge will always be removed from the belt in consequence of the Faraday "ice pail" effect. The upper limit to the voltage available is reached when the charge is lost from the sphere at the rate at which the belt can convey it. By a suitable arrangement of the brushes and inductors the current output can be doubled by giving the down-going side of the belt an equal, but opposite, charge from the sphere. This also makes the machine independent of the magneto except for starting up. The current available is about 30 micro-amperes.

A new constant-potential system, to which the name "Noreg" has been applied, was demonstrated by the Westinghouse Brake and Signal Company, Ltd., of 82, York Way, King's Cross, N.1. It provides, in addition to compensation for variation in load, compensation for variations in input voltage without the use of saturated chokes, gas discharge tubes, or barretters. The equipment comprises, in addition to a metal rectifier, two transformers and a condenser. A low percentage ripple in the output voltage is achieved not only by providing constancy of mean voltage, but also constancy of instantaneous voltage by the conversion of single-phase power

FIG. 25—VAN DER GRAAF ELECTROSTATIC GENERATOR

to three-phase power at medium and large loads, and by the production of a flat-topped rectifier input wave at light loads and open circuit. As the material in the equipment is all used at economical densities, the capital cost and efficiency do not differ much from that of a rectifier and transformer of ordinary design. A 600-watt set working at full load has an efficiency of 70 per cent. and a power factor of 0·94. A set of this size will provide at constant load an output voltage varying by only ±1 per cent. for a variation in main's voltage of ±10 per cent. The output voltage can be made to fall or rise with an increase in load according to requirements.

A modification of the "Noreg" constant-potential system is known as the "Westat" floating battery system. In the past the difficulty with all rectifier constant-potential charging systems has been to avoid a great magnification of main's voltage variation effect upon the charging rate. The ideal to be aimed at is that as long as the mains remain alive the trickle charge to the battery will remain as nearly constant as possible at a predetermined value, irrespective of load variations and main's voltage. It is also desirable that the battery should be solidly connected to the load without intermediary pieces of apparatus, such as choke windings, contactors, &c. A modification of the "Noreg" constant-potential system clearly lends itself to the attainment of this end.

In both types of apparatus the A.C. portion of the equipment operates in the same way, but the adjustments may be a little different. Two transformers (Fig. 26) are employed, together

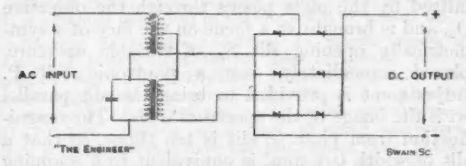


FIG. 26—CONSTANT POTENTIAL SYSTEM—WESTINGHOUSE

with a condenser. The circuit arrangements and the design of the transformers are such that at full load the E.M.F. of one transformer leads the phase of the mains voltage by about 45 deg., while the E.M.F. of the other transformer lags behind the phase of that voltage by about the same amount. By the Scott connection on the secondary side of the transformers an approximately balanced three-phase voltage is applied to the three-phase bridge-connected rectifier. The design is also such that as the load is reduced, the phase angles of the two transformers tend to swing together with the result that the three-phase output from the secondaries is thrown out of balance, and one phase ceases to operate. The main output of the rectifier can be adjusted so as to diminish at about the same rate as the

internal resistance in the rectifier diminishes, thus maintaining a constant-output voltage irrespective of load.

The flux density at which the transformers operate is also proportioned so that a similar correction takes place for variations in input voltage, thus making the output voltage independent not only of load current variations, but also of mains voltage variations.

In the "Westat" floating battery system adjustments have to be made to a very good degree of accuracy. It is possible to operate a battery floating in parallel with the system and yet maintain the battery always in a state of small trickle charge. The "compounding" of the rectifier ensures that the supply mains supply the power to the load, and does not allow the battery to carry any of the load until the mains supply fails. Moreover, the battery is not excessively charged under any condition of load or mains voltage.

Dr. E. M. Guénault and Dr. H. Lloyd, of the Safety in Mines Research Board Laboratories, Sheffield, were exhibiting, among other things, a recording microphotometer. Examples were shown of its application to the analysis of X-ray diffraction negatives of metals, such as fractures in chain links, to the evaluation of thermal dust precipitator slides, and as a recording densitometer in connection with surveys of mine-lighting conditions by photographic photometry.

The instrument is illustrated in Fig. 27, and the disposition of the optical and recording system is shown in Fig. 28. The main optical axis A B is vertical. Light from a 12-volt, 36-watt straight coil filament F is brought to a focus N on the spectrogram under observation in the form of a negative by the condenser O_1. The light transmitted by the plate passes through the objective O_2, and is brought to a focus on the face of a symmetrically opening slit S_1, of variable aperture, placed immediately over a photronic cell P. Adjustment is provided to bring the slit parallel with the image of the spectrum lines. The magnification from plate to slit is ten times, so that a slit of width 0·1 mm. is equivalent to a scanning slit of 0·01 mm. in the plane of the plate.

The current generated by the photronic cell is passed through a short-period D'Arsonval galvanometer G, and the deflection is recorded photographically. Light from a slit S_2, illuminated by the lamp L, passes to the galvanometer mirror M, and the reflected beam is focussed by a cylindrical lens C on to bromide paper wrapped around the drum D. The stage carrying the photographic plate is mounted on a geometrically constructed carriage, which travels horizontally on hardened and ground steel rails at a slow controllable speed across the bed of the instrument, so that the slit scans the spectrum from end to end. Provision is made for the rotation of the plate in the carriage to bring the spectrum exactly parallel with the line of travel of the moving carriage. A rack and pinion movement for transverse adjustment is also included. The plate carriage is anchored to an endless steel ribbon, maintained in tension by a spring and passing over two pulleys. The ribbon is positively attached to one of the pulleys which is geared to the shaft of the camera drum. Thus the motion of the carriage bears a definite relation to the rotation of the drum, and a linear magnification of plate movement to travel of the recording paper is obtained. The camera drum is slowly rotated by a governor-controlled clockwork motor to which it is connected through reduction gears. Interchangeable pulleys of different diameters are provided for covering a wide range of magnifications. Means are provided by which a co-ordinate system is simultaneously photographed on the record to avoid inaccuracies of measurement, owing to changes in the dimensions of the bromide paper on processing.

One of the exhibits of Marconi-Ekco Instruments, Ltd., of Electra House, Victoria Embankment, W.C.2, was the wave analyser shown diagrammatically in Fig. 29. It is for the direct measurement of the components of complex voltage waves having amplitudes of 300 microvolts to 300 volts in the frequency range from 20 to 15,000 c.p.s. The equipment can also be used for the measurement of the audio-frequency modulation of R.F. signals having amplitudes of 1 to 10 volts. The wave analyser is a super-heterodyne value voltmeter, with a very sharply tuned intermediate frequency amplifier. In a balanced modulator the test signal is mixed with a local carrier signal, which is variable in frequency from 35 kc/s. to 50 kc/s. The local oscillator is adjusted so that the sum of the carrier frequency and that of one of the components of the test signal is maintained at 50 kc/s. Consisting of the upper and lower sidebands, the output of the modulator is applied to a calibrated attenuator followed by a highly selective three-stage amplifier incorporating a crystal filter, in which the lower sideband is eliminated. The output of the amplifier is applied to a direct-reading valve voltmeter. A ring bridge of copper oxide rectifiers in the balanced modulator suppresses the carrier to a level at least 40 db. below that of the desired signal. Each interstage coupling of the amplifier is provided by a mixed capacity and mutual inductance band pass filter in which iron-cored coils with a high magnification factor are used. The crystal filter connected between the first and second stages of the amplifier comprises two 50 kc/s. quartz bars in series and the circuit is arranged so that a true band pass characteristic is obtained, *i.e.*, the selectivity curve has a flat top covering about 4 c.p.s., while outside this range the attenuation rises very rapidly, the response being 50 db. down at 30 c.p.s. off resonance. The balanced modulator is preceded by a valve circuit of negligible distortion and an excellent frequency characteristic. For audio frequency inputs the valve serves as an impedance converter and unity gain amplifier, whilst for measurements on radio frequency carrier envelopes it operates as a diode detector.

The tuning condenser of the local oscillator is graduated directly in input frequencies, *i.e.*, the difference between the oscillator frequency and 50 kc/s. Three multipliers operated by a single switch are used when measuring audio frequency voltages in the range from 300 millivolts to 300 volts. The power supply is derived from batteries housed in a separate compartment in the instrument.

(To be continued)

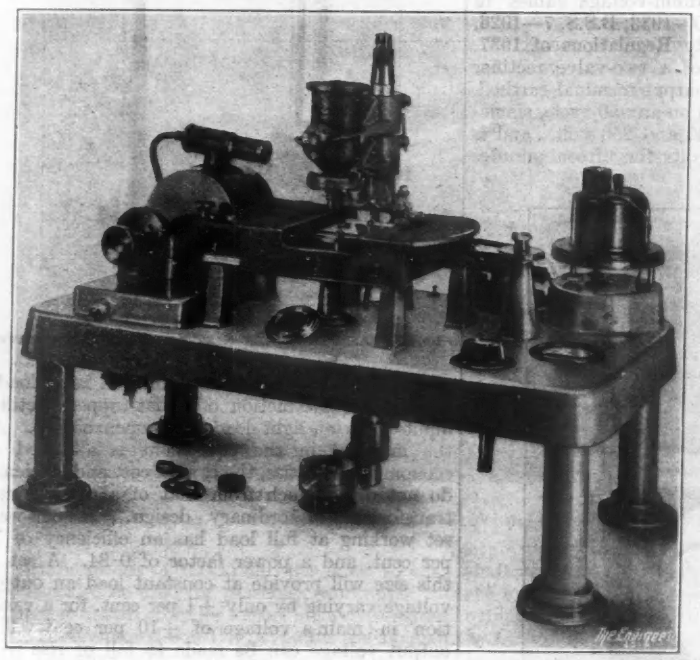


FIG. 27—RECORDING MICROPHOTOMETER

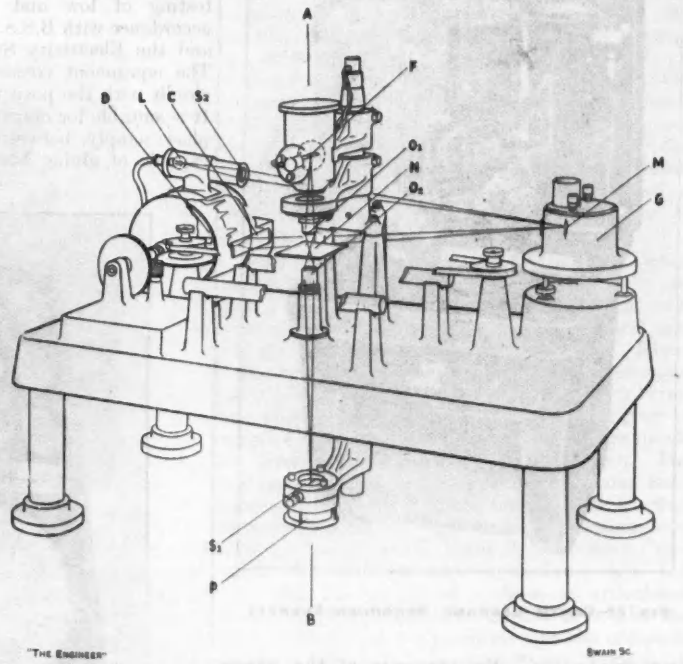


FIG. 28—DETAILS OF RECORDING MICROPHOTOMETER

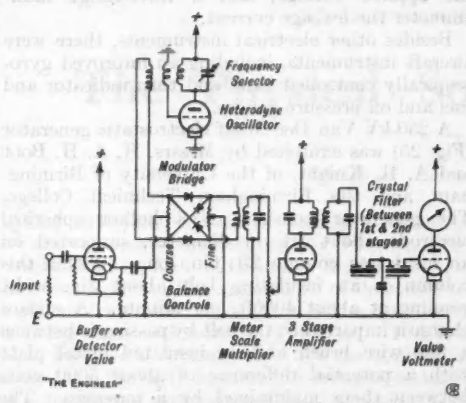


FIG. 29—WAVE ANALYSER—MARCONI

THE LATE MR. H. STONEWALL JACKSON.—We regret to have to announce the death on January 5th of Mr. H. Stonewall Jackson, for many years manager—and latterly a director—of Spencer-Bonecourt, Ltd., 32–33, Farringdon Street, London, E.C.4. Mr. Jackson retired from active work only three months ago. He was originally with Richardsons, Westgarth and Co., Ltd., of Middlesbrough, and was closely associated with the late Mr. Tom Westgarth in the development of that firm's specialities, both in the marine field and in steel works machinery, including rolling mill engines and the mechanical gear for large tilting furnaces. Mr. Jackson had a service record of some sixteen years with Spencer-Bonecourt, Ltd., and was connected with that firm's activities as waste heat recovery specialists in steel works and gas works practice. He was a Past-President of the Cleveland Institute of Engineers.

NEW BRISTOL RING ROAD.—Further progress will be made this year in carrying out schemes for the relief of traffic congestion in the streets of Bristol. The schemes aim at diverting the streams of through traffic into new and more commodious channels. One of the new routes will take the form of an inner ring road on the south side of the city, and part of it, known as Airport Road, has already been built. Another, consisting of Eastern and Western Road, is nearing completion and a grant from the Road Fund was made recently for the bridge over the floating harbour, which represents the last stage of the scheme. The Minister of Transport has now made a grant to the Bristol County Borough Council for the construction of a 2-mile section of the inner ring road. The section of new road, which is estimated to cost nearly £140,000, will form a continuation of Airport Road and when completed will provide a link between the two highways entering the city from Bridgwater and Wells. Short lengths of two existing roads, Vale Lane and Parson Street, will be incorporated. For nearly a mile the line of the new road follows a narrow valley and the construction will involve so much excavation and filling that the attainment of the ultimate width is not considered at the present time economically practicable. Sufficient width will be obtained, however, to allow for dual 22ft. carriageways and footpaths.

Rail and Road

PROPOSED UNDERGROUND RAILWAY IN LEEDS.—A proposal has been placed before the Leeds Traffic Advisory Committee for the construction of an underground railway which would also be used as a municipal air raid shelter. It would be 12¾ miles long and cost over 6 million pounds to build.

THE TRANSANDINE RAILWAY.—A Bill for the purchase and rebuilding of the Argentine Transandine Railway has been approved by the Argentine Senate. This line was a British enterprise and was first opened in 1910. It has been closed since a landslide destroyed part of the line in January, 1934.

THE TRAMWAYS' RETURNS.—The annual return of the Ministry of Transport for the tramways and light railways and trolley vehicle undertakings shows that there has been a decrease of 106 route miles of tramways, leaving the present electrified mileage of 999. These figures do not include the London Passenger Transport Board's system, which worked 175 route miles in the year ended June 30th, 1938, as compared with 226 miles the previous year. Omitting the L.P.T.B., the route mileage of trolleybuses increased by 29 to 445. The L.P.T.B. trolleybus routes increased to 198 route miles by June 30th, 1938, as compared with 122 miles the previous year.

FARES IN THE LONDON AREA.—Following a recommendation by the Standing Joint Committee, the London Passenger Transport Board and the main line railway companies are making application to the Railway Rates Tribunal for permission to increase passenger charges by 5 per cent. or thereabouts. The increase will also apply to certain railways owned jointly by the L.P.T.B. and main line companies and certain sections of the railways owned by the latter companies over which the L.P.T.B. trains provide a service. The L.P.T.B. also proposes to increase certain fares on its railways which are not included in this application to the Railway Rates Tribunal. It will also increase certain fares on the tram, bus, trolley-bus, and coach services.

LOADING OF THE "CORONATION SCOT."—Loading of the "Coronation Scot," the first complete train ever to be shipped from the port, began at Southampton docks on Thursday, January 19th, and will continue until January 24th. The "Coronation" did not travel to Southampton under her own steam, but with connecting-rods and other projecting gear packed-up securely for the 2000 miles sea journey, was hauled "dead" by a Southern Railway Company locomotive. The coaches, covered with a coating of wax to protect them from exposure, and all movable fitments securely lashed, formed a separate train. The eight coaches, lashed and screw coupled, are to travel as deck cargo, whilst the engine and tender will be stowed in the ship's hold.

SLIPPING OF LOCOMOTIVE DRIVING WHEELS.—A series of tests have been carried out by the Baltimore and Ohio Railroad in the United States on the conditions under which rails are "burned" by the slipping of locomotive driving wheels. It was found that at least three rails were usually damaged when such slipping took place, and the cost amounted to as much as 52 dollars if the rails were injured sufficiently to require replacement. As a result of the tests, the railway company has issued a number of instructions to the engine drivers to avoid or reduce such slipping. These instructions include the opening of rail sanders just before the engine comes to rest, open sanders before opening throttle, and as soon as the train has started the throttle should be eased off and then gradually opened to the desired position, as soon as it is felt this can be done without driver slip taking place.

TRANSPORT IN THE UNITED STATES.—A committee set up to study the difficulties of the railways in the United States has submitted its report to the President. It is stated that the cause of the present national transport problem is the absence of a clearly defined policy which intensifies wasteful competition, unequal regulation, anh inequitable subsidies. The committee recommends that a transportation board be set up to report upon the relative economy and fitness of the various modes of transport and the extent to which any of them is now being subsidised, with recommendations for further legislation. Thereafter, this board would be responsible for the unified development of the country's transport system and exercise control over all branches, except with respect to rates and accounting. It is recommended that the present plan, whereby the Interstate Commerce Commission is required to develop a consolidation plan for the entire railway system, should be discarded.

RAILWAY STATISTICS.—Railway statistics for the calendar month of September and the four weeks ended October 1st, 1938, show that the total number of passenger journeys, excluding season ticket holders, taken on all standard gauge railways in Great Britain in the month of September, 1938, was 103,336,309, a decrease compared with September, 1937, of 7,633,437, or 6·9 per cent. The journeys taken by passengers at reduced fares decreased by 5,506,277, and those at standard or ordinary fares by 2,127,160. The receipts from passengers, excluding season ticket holders, showed an increase of £82,722, or 1·6 per cent. If the railway undertakings of the London Passenger Transport Board be omitted, the figures show a decrease in journeys of 5,812,645, or 7·6 per cent., and an increase in receipts of £103,435, or 2·2 per cent. For all railways the receipts from passenger train traffic, including season tickets and parcels and miscellaneous traffic, but excluding mails and parcels post, was £67,206 more than in September, 1937. For the four weeks ended October 1st, 1938, the coaching train miles showed an increase of 358,483 compared with the four weeks ended October 2nd, 1937. The total tonnage of freight conveyed, excluding free-hauled traffic, in the four weeks ended October 1st, 1938, was 19,791,377, a decrease compared with the corresponding four weeks of 1937 of 16·1 per cent. The freight train receipts amounted to £6,762,930, a decrease of £694,872, or 9·3 per cent. The freight train miles run were 889,924 less than in the corresponding period of 1937, a decrease of 8·1 per cent. The average train load decreased from 131¼ to 122¾ tons and the net ton-miles per engine hour decreased from 475½ to 460½.

Miscellanea

STEEL FACTORY IN EIRE.—Work is rapidly proceeding in connection with the steel factory which is being built on Haulbowline Island in Cork Harbour. It is expected that the new industry will eventually fulfill all of Eire's steel requirements.

NOVEL USE FOR X-RAY.—An oil cake factory in Odessa is making use of X-ray to detect injurious admixtures in its products. Two engineers at the plant have constructed a special device for this purpose. The oil cake is carried on a conveyor past an X-ray screen upon which foreign substances are immediately reflected. The operator has only to press a button to mark the defective cake with a distinctive colouring and to separate it from the pure products.

THE ELECTRICAL INDUSTRY IN THE UNITED STATES.—According to statistics compiled by Mr. C. W. Kellogg, President of the Edison Electric Institute, during 1938 there was a net increase of 1,000,000 kW of generating capacity installed in the United States, making the industry's installed generating capacity 36,000,000 kW. The industry's 27,765,000 customers purchased about 93,400 million kilowatt-hours during the year. Mr. Kellogg estimates that the country's electric utility industry spent 470 million dollars on construction work.

THE PRODUCTION OF COAL.—The statistical summary of the Mines Department, showing the working results of the coalmining industry during the third quarter of 1938, shows that the output of saleable coal amounted to over 50,597,000 tons. Of this amount, 46,917,000 tons was disposable commercially, of which 11,489,681 tons were shipped for export or foreign bunkers. Pithead proceeds averaged 17s. 2·68d. a ton and net costs of production averaged 16s. 6·02d. a ton. The output of each man-shift worked was 22·53 cwt., and earnings averaged 11s. 2·97d. a shift.

A.R.P. TRENCHES.—The Government's approval has been given to a revetment design utilising *in situ* concrete as a means of completing trenches dug for air raid protection purposes. A design has been planned to meet the loading requirements set out in the Home Office A.R.P. Department's "Specification in Regard to Permanent Lining of Trenches," providing concrete walls and roof, 4½in. thick, reinforced with ⅜in. diameter steel bars. Copies of the drawing approved by the Government are obtainable free of charge from the Cement and Concrete Association, 52, Grosvenor Gardens, London, S.W.1.

HYDRO-ELECTRIC PROGRESS IN CANADA.—According to the annual review of hydro-electric progress in Canada, new water power installations in 1938 aggregated 135,459 H.P., bringing the total for the Dominion at the end of the year to 8,190,772 H.P., after this total had been adjusted following a general revision of plant ratings. The greater part of the increase was made up of extensions to existing stations in British Columbia, Manitoba, and Quebec. The more important new developments were the 10,200 H.P. Cowie Falls development of the Nova Scotia Power Commission on Mersey River, the 10,400 H.P. plant of the Hydro-electric Power Commission of Ontario at Ragged Rapids on Musquash River, and the 10,000 H.P. development of the Great Lakes Power Company at Lower Falls on Montreal River in Ontario. The 1938 increase was distributed by provinces as follows:—British Columbia, 48,459 H.P.; Manitoba, 12,500 H.P.; Ontario, 20,400 H.P.; Quebec, 43,400 H.P.; and Nova Scotia, 10,700 H.P.

INTERESTING ADDITION TO SCIENCE MUSEUM.—A recent addition of some interest to the Science Museum is a replica of the Woolrich electromagnetic machine of 1844. The original dynamo of Faraday (1831) and those which followed during the ensuing thirteen years were all laboratory instruments rather than practical machines. In 1844, however, the first industrial electric generator, a massive contraption of wood, iron, and copper, weighing over half a ton, was made by an Englishman to supply current to two plating baths at the works of Messrs. Prime, of Birmingham. With this machine, the original of which is at the Birmingham Historical Museum, industrial electrical engineering may be said to have been born. It is little known, and this full-sized replica, built by permission of the Director of the Birmingham Museum, may serve to increase the knowledge that yet another great industry had its roots in this country. Particular care was taken in the museum workshops to obtain a finish and general appearance consistent with the workshop facilities of a hundred years ago.

ENGINEERS' GERMAN CIRCLE.—The first meeting of the present year's session of the Engineers' German Circle took place on Monday evening, January 16th, at the Institution of Mechanical Engineers, when the lecture was given by Dip.-Ing. E. Grund, of Dusseldorf. Herr Grund, who is a member of the firm of Schiess-Defries, took as his subject "The Recent Development of Machine Tool Construction, with Special Reference to Heavy Machine Tools." The lecture was outstanding, not only for its matter and well-chosen illustrations, but on account of its clear delivery. After dealing briefly with the historical aspect of his subject, the lecturer outlined the developments which had taken place within the last few years, which, he stated, had been prompted by the better metallurgical properties of metals, the introduction of high-speed steel and carbide alloy tools, and the findings of scientific research. In describing the qualities of the ideal machine tool, Herr Grund said that the objects to be attained in any new design should include the shortening of the working and setting-up times, the reaching of the highest accuracy consistent with the class of work for which the machine was intended, the simplification of controls, and a general harmony of design. He then proceeded to show how these desirable qualities had been embodied in the design of heavy machine tools, not only in the case of the very large tools associated with the name of Schiess-Defries, but also in representative designs of other German machine tool firms. Finally, he made reference to the newer methods of surface removal, such as broaching, grinding, and diamond boring, also pressure polishing. Following the lecture, an informal dinner was held at Oddenino's Restaurant.

Air and Water

SHIPBUILDING IN JAPAN.—Japanese shipping companies have eighty-four ships, totalling 521,740 tons, at present under construction. It is planned to launch all these ships during the current year. It is also proposed to launch 114,190 tons of shipping in 1940 and five ships of 72,500 tons in 1941.

RECORD PARIS TO LONDON FLIGHT.—On its journey from Le Bourget to Croydon the Supermarine "Spitfire" fighter, which was shown at the Paris Aeronautical Exhibition, covered the 205 miles in 41 minutes. In making this record flight, the machine is stated to have had little help from the wind, and climbed to a height of 18,000ft. in the course of the journey.

TYNE FERRY SERVICES.—It is announced that another Tyne ferry service is likely to be withdrawn. It is the one between Hebburn and Wallsend, which was begun about seventy years ago by R. and W. Hawthorn, Leslie and Co., Ltd., for their workmen. The company has announced that it will close the ferry to the public on June 30th next, and make arrangements for the transport of its own workers.

AIRCRAFT ACCIDENT.—Air Vice-Marshal H. M. Cave-Browne-Cave was seriously injured last Tuesday when the aeroplane in which he was travelling with his personal assistant Flying Officer Geoffrey Beavis crashed in Tangham Forest. Flying Officer Beavis was killed. Air Vice-Marshal Cave-Browne-Cave is brother to Professor Cave-Browne-Cave of Southampton University College. He was in charge of the far east flight of four Napier flying boats in 1927 when 27000 miles were covered without any kind of mishap.

MILLWALL DOCK IMPROVEMENTS.—The Port of London Authority has decided, with the object of providing improved facilities for Swedish trade, to reconstruct the north quay of the Millwall Outer Dock and to erect two two-storey quay sheds, 432ft. long and 100ft. wide. The work will involve deepening the dock to 29ft., the remodelling of the existing road and railway lines, and incidental work. The cost of the scheme is estimated to be about £200,000, and to minimise any possibility of inconvenience to shipping the work will be carried out in two stages.

NEW SHIPS FOR HARWICH AND FLUSHING SERVICE.—The first of two new 3500-ton motorships for the Harwich and Flushing service of the Zeeland Steamship Company was launched on Saturday, January 14th. This ship was named the "Koningin Emma," and its propelling machinery consists of two two-stroke engines of 13,000 H.P., giving it a speed of 23 knots. With a carrying capacity of 1900 passengers, it also has 60,000 cubic feet of cargo space and accommodation for twenty-four motor cars between decks. A sister vessel, the "Prinses Beatrix," is to be launched next month.

RETRACTABLE OBSERVATION DOMES ON FLYING BOATS—In order to facilitate the work of the navigating officer, when taking observations on the Imperial Airways long-range flying boats, a transparent retractable dome is being fitted. The dome will be placed above the part of the fuselage where the navigating officer will have his chart table and apparatus. It will normally lie within the machine, and when observations are required, it will be raised through a hatch and project just far enough above the fuselage to accommodate the head and shoulders of the officer when using his instruments.

A SHIPPING DEPUTATION.—On Tuesday, January 17th, the President of the Board of Trade received a deputation of shipowners representing the various sections of the industry which have collaborated in the production of the report of the Joint Shipping Policy Committee of the Chamber of Shipping and the Liverpool Steam Ship Owners' Association. The shipowners elaborated the proposals they had put forward and the arguments in support of them. The President asked for further information on various points, and it was arranged that representatives of the different sections of the industry would be available for discussions with the Department.

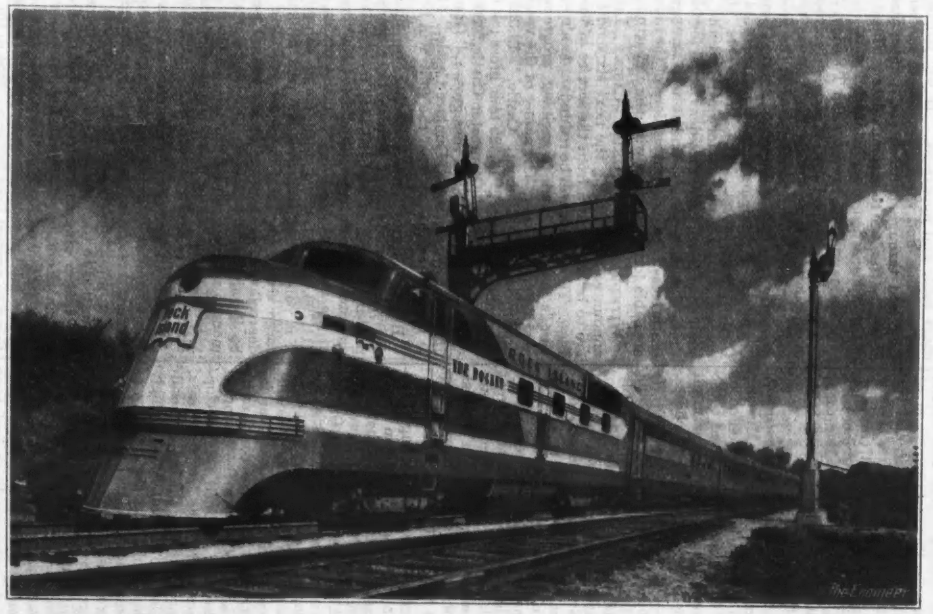
WITHDRAWAL OF UNION-CASTLE LINERS.—It is announced that during the next six months seven liners are to be withdrawn from the service of the Union-Castle Line. These ships will be redundant as a result of the company's building and re-engining programme, which is nearing completion. The names of the vessels to be withdrawn are:—"Balmoral Castle," 13,363 tons gross; "Edinburgh Castle," 13,329 tons gross; "Garth Castle," 7625 tons gross; "Gloucester Castle," 8006 tons gross; "Durham Castle," 8240 tons gross; "Grantully Castle," 7592 tons gross; and "Dunluce Castle," 8131 tons gross. It is expected that most of the ships will be broken up.

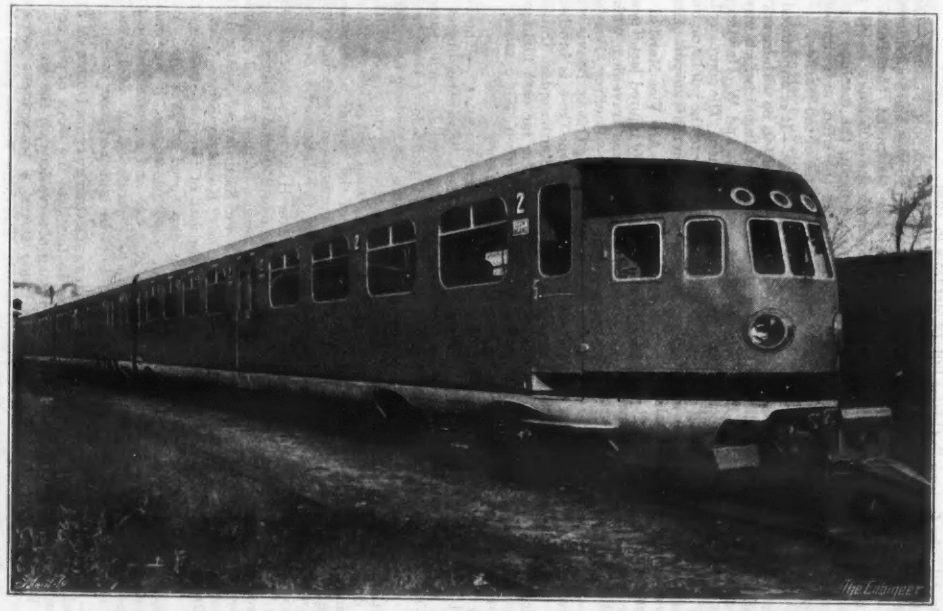
BRITISH SHIPPING.—According to figures given in *Fairplay*, twenty-eight British liner companies, with a paid-up capital of £59,495,444, reserves of £27,350,731, and owning fleets aggregating 5,404,353 tons gross, valued in the books at £68,978,155, made profits on voyages of £11,793,789. Dealing with cargo shipping companies, it is pointed out that over the past fifteen years British cargo ship companies have earned, after providing for depreciation, an average of less than 1 per cent. on the book value of the fleet to provide interest on borrowed money, reserves, and dividends. A chart shows that the value of a new, ready, 7500-ton cargo steamer has dropped during the past fifteen months from £125,000 to £85,000.

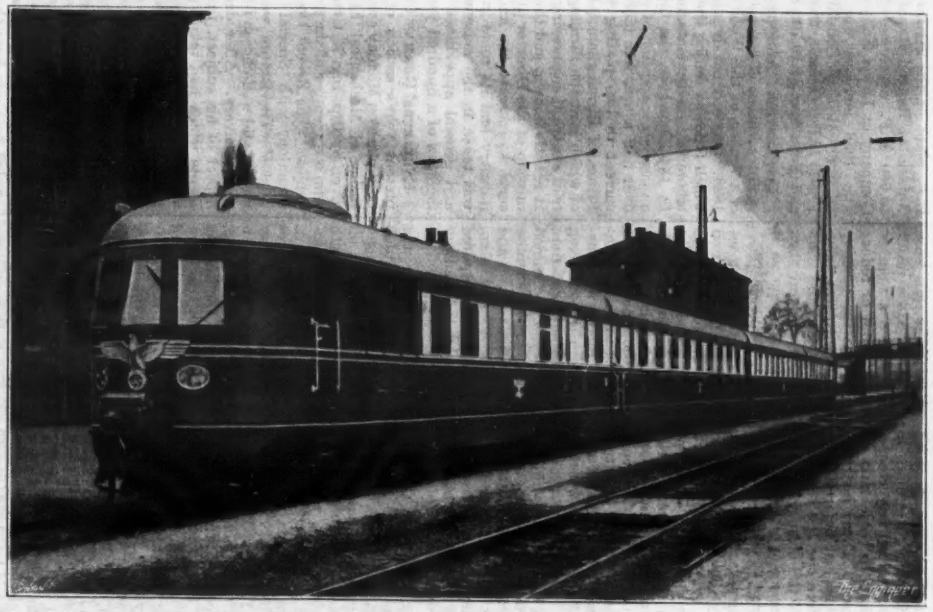
PROPOSED SHIPPING SUBSIDIES AND DEFENCE LOAN.—The Chamber of Shipping and Liverpool Steam Ship Owners' Association has prepared a scheme for the rehabilitation of all branches of British shipping, which is to be submitted to the Government. The scheme proposes that the tramp shipping subsidy should be renewed, with certain alterations to detail, for five years to the amount of £2,500,000 annually; the setting up of a defence fund of five million pounds annually for five years for deep-sea liners to support liner services; that in the near Continental trades the Government should insist on an increasing proportion of United Kingdom timber imports from Russia being carried in British ships, the greater employment of British shipping in the timber trades from other countries and in the coal export trade from this country to the Continent; and a subsidy of half a million pounds annually for at least five years on the same conditions as the deep-sea tramp subsidy.

OIL-ENGINED RAIL TRACTION IN 1938

(For description see page 87)







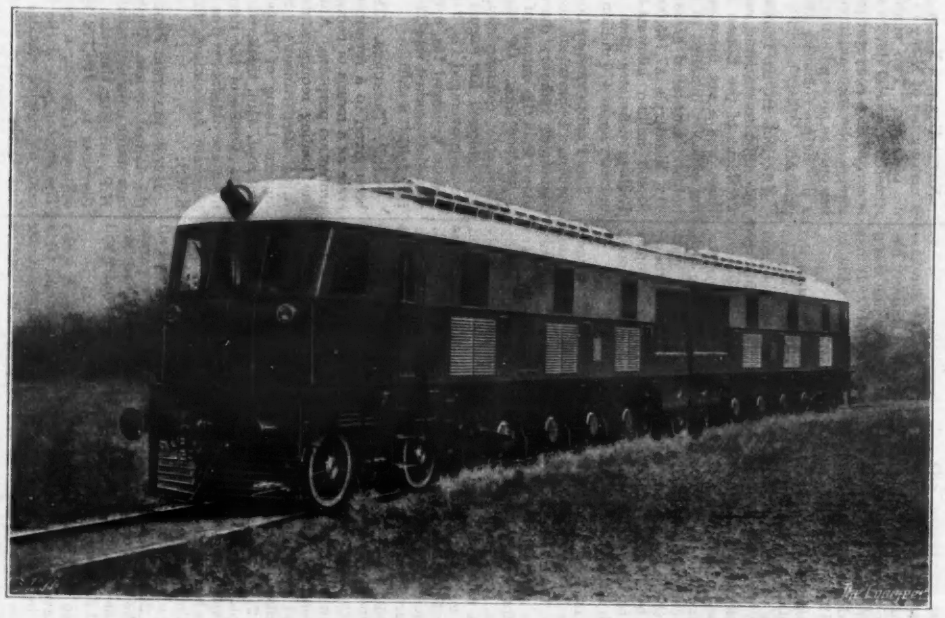


FIG. 36—1200 H.P. "ROCKET" TRAIN FOR CHICAGO, ROCK ISLAND AND PACIFIC RAILROAD
FIG. 38—1350 B.H.P. OIL-ELECTRIC TRAIN FOR GERMAN RAILWAYS—M.A.N.

FIG. 37—820 H.P. ARTICULATED TRAIN FOR NETHERLANDS STATE RAILWAYS—WERKSPOOR
FIG. 39—4400 B.H.P. OIL-ELECTRIC LOCOMOTIVE FOR ROUMANIA—SULZER

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INDEX TO VOLUME CLXVI.

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THE TRANSPORT PROBLEM STATISTICALLY

IT is felt that little apology is needed for drawing attention once again to the transport problem, which appears to be fast approaching a crucial stage. Whilst far removed from being wholly an engineering matter, nevertheless, the life and activities of numberless engineers—civil, mechanical, and electrical—are bound up closely with the fortunes, or, perhaps more truly, present misfortunes, of the transport industry. Some of the most important railway departments are those of the civil and mechanical engineer; on many railways the electrical engineering department is of considerable and growing importance. Road transport provides work for large numbers of automobile engineers, and road construction, to-day a highly specialised study, occupies the full-time thoughts of many civil engineers. Coastal shipping, inland waterways, docks, and ocean transport services all place heavy calls on the best engineering brains, both on the construction and the maintenance side. In brief, the engineer is the creator of the transport system, and without his ever-present attention and endeavour the complex service which the British and world consumer requires would rapidly descend into irretrievable chaos. Such is the direct connection between the engineer and transport, but the indirect relationship is as important. Production can only be efficient and make progress if distribution of raw materials and manufactured products flows freely and punctually in its wonted channels. If the transport system should break down the forces of production would be stayed, if not stopped, and thus indirectly nearly all branches of engineering would be affected. The railways, in the campaign for a square deal, have equally squarely hinted that there is grave danger of an economic breakdown of the transport services unless remedial action is rapidly taken, their proposal for such action being the abolition of restrictions on their freedom to quote charges for their haulage services. At the moment their proposals have been remitted by the Minister of Transport for deliberation by the Transport Advisory Council, an action both appropriate and timely; but the present indications are that an agreed recommendation by the varied interests on this Council is unlikely, and, therefore, the probability exists that discussion on a wider basis involving, maybe, Parliament, the Press, and the public will take place.

Recalling the dangers which have sometimes attended the search for the most suitable policies on similar previous occasions, we think it well to place on record something of the general background of this question. The first outstanding feature is the way in which this same transport, or, in Transatlantic terminology, transportation, problem has defied every known form of Government—democratic, socialistic, or dictatorial. Turn where one will—to the United States, to France, to Germany, to Italy, to India, to Australia, or to the South American Republics—one finds that in the domestic sphere it is the transport problem which gives cause for most anxiety. The coming of the motor vehicle, its flexibility and the inherent difficulties of enforcing regulations in respect of its movement, has brought in its train a multiple load of problems; for instance, the financing of track by loans or taxation, its relationship to other forms of existing transport, and its dependence, perhaps, upon an imported fuel. These are merely different facets of one large problem, a veritable revolution of an industry. No country as yet has found a complete or satisfactory solution. Our own railways' square deal campaign itself proves that we have not; but how have others fared? President Roosevelt, in his famous election speech at Salt Lake City, pointed out the essentials towards solution; yet to-day, the American transportation problem is more acute than ever, with over a third of the country's railway mileage in trustee or receivership and a further third in dire financial straits. If there is any problem the United States cannot claim to have solved it is this. The French Finance Minister recently drew attention to the importance of railway deficits in the country's financial difficulties, and even with complete amalgamation and the adoption of national ownership 1938 results are expected to show a working deficit of over £13,000,000, making no allowance for any interest on capital investment. In Germany the efficient Reichsbahn has an operating ratio as high as 94 per cent. (compared with the British ratio of about 80 per cent.) which leaves virtually nothing for interest on capital, although there is no unemployment, traffic is making new records each year, and the Reichsautobahnen are earning practically nothing on their colossal investment. In Denmark and Switzerland the Governments are having to make good interest charges on their State-owned railways; the Canadian railway problem fills newspaper columns, has invaded political programmes, and is common talk on the domestic hearth. The trials and tribulations of Argentine railways are too well known to require stressing, and in Australia and New Zealand deficits after fixed charges have been paid are the rule rather than the exception; India but recently appointed the Wedgwood Committee of Inquiry.

Enough has been said to prove the world-wide nature of the problem, intractable to democracy, socialism, and dictatorship alike. Our own problem is, however, the one which lies at our door, and looking for guidance we have been struck by the second main characteristic of this issue, which is in essentials one of rail and road relationship. Any proper approach must be based on an analysis of relevant data, but, whilst a plethora of railway statistics seems to exist, there is apparently an almost complete lack of similar figures covering road transport. We are aware of the Traffic Commissioners' Reports, but they refer only to passenger movement, and this, at any rate in Great Britain, is not the cause of the trouble whatever may be the case in France and the United States where certain figures show that the railways conduct this work at a loss. Such is not the case here as witness the comparative prosperity of the Southern Railway, 75 per cent. a passenger line. Even the London Passenger Transport Board's financial problem is one only affecting the "C" stockholder and him to a minor extent. True, one can obtain from the reports of the licensing authorities the number of road haulage vehicles of A, B, and C category, and elsewhere the number of new vehicles registered, yet these give no hint of the volume of tonnage handled, the ton mileage and vehicle mileage, without which analysis of the problem is almost impossible. Germany, however, now possesses such data for all road traffic exceeding a haul of 31 miles and figures for 1937 were recently published. In contradistinction, the plenitude of railway statistics is almost overwhelming, and can only be expertly assessed after detailed study. It is with the object of elucidating them that we propose to publish soon a short survey of the outstanding features of these figures and the trends they show. We trust it will prove helpful to our readers in guiding their judgment in view of the present complex situation.

Plastic Materials for Aircraft

IN their unremitting pursuit of higher and higher performance in the aircraft they plan, designers are continually on the watch for materials of construction even lighter, in proportion to their weight, than those now in use. At present aluminium, in one of its alloyed forms, is the material most used. Dural, for example, has much the same ratio of tensile strength to density as a high-quality steel, though it is much more useful than the latter for any purpose where the quality of stiffness is required. This is naturally so, since its lower density is accompanied by a greater thickness of section, and consequently an improved degree of stability under other stresses than the simplest.

Some two years ago Dr. de Bruyne, of Cambridge, communicated to a meeting of the Royal Aeronautical Society the results of his efforts up to that time to produce a plastic material, of the reinforced synthetic resin type, which would be suitable for use in aircraft construction. The material then described had a ratio of tensile strength to density almost equal to that of dural; in its composition cotton fibre was employed as the reinforcement. Although much work has certainly been done both here and in American and in Germany to find a plastic which will not merely equal dural, but will markedly improve upon it, little has so far been allowed to be published as to the results attained. In present circumstances this is but natural. We live in days in which foreign policy is air power, and no country cares to give much advance information. Dr. de Bruyne has, however, lately given an account of the position reached after two years' further work. In the course of his investigations he found it an improvement to use linen threads instead of cotton as his reinforcing material, with the reported result of an improvement in the ratio of tensile strength to density of not less than 60 per cent., so easily beating both dural and high-grade steel. Moreover, the material has only half the density of dural and less than one-fifth that of steel. This is a striking result and if it is confirmed by further work it will become important to consider the use that can be made of this substance in aircraft construction. Instinctively one thinks of mechanical presses producing wings and large fuselage parts in considerable numbers, but although this may indeed happen in the years to come, the producer of this material not unnaturally suggests a less ambitious and less costly start by building what may be termed "planks"—apparently of any desired length—which can be cut up or shaped to

form wing spars or any other highly stressed structural members. These planks are produced in a specially devised machine, which draws the loose fibres into a uniform band which then enters an impregnating bath and is subsequently dried and compressed at a carefully adjusted temperature. The claim made for the material so produced is that it has not only an unusually good strength-to-weight characteristic, but that it can be produced in almost unlimited lengths, easily built up into structures capable of withstanding heavy loads. It is, of course, free from any corrosion trouble. It is not, however, a material which lends itself to riveting or bolting, or even to glueing, so that a new technique for fastenings and joints has had to be designed. But it does certainly seem that it may afford an opportunity to reduce the percentage structure weight of aircraft, possibly to facilitate their construction, and to reduce their cost of manufacture in man-hours.

Since the total weight of an aeroplane is divisible into structure weight, power plant and fuel weight, and useful load, a saving in structural weight enables more fuel to be carried, and therefore a greater flying range to be obtained. This is one of the chief goals which the aeroplane designer sets steadily before him and he welcomes, therefore, any new material, however revolutionary in form, which offers a promise of help in reaching it. Let it be admitted that the ratio of tensile strength to density, important though it may be, is not everything. Consideration must also be given to strength in shear and the elasticity of the material. Moreover, even when this has been done, the designer must be prepared for such changes in structural form as will suit the special aptitudes of this—as of any other—new material. Forms suited to such intensive work as the multitudinous riveting now so common can hardly be expected to prove the most suitable for a simpler type, in which individual joints may be almost as rare as now they are common. The existence of such a possible material is a stimulating challenge to the aeronautical engineer, and it is to be hoped that the solution will be attained here without waiting, as seems to the onlooker to have so often happened in the past, for a lead to come from some other country before an innovation is accepted. The stimulus might, it is true, come from Air Ministry requirements, but the Air Force, although like the Navy, a highly mechanised service, has not in its twenty years of existence embodied, into its higher direction, the kind of professional skill which one associates instinctively with such an office as that of the Director of Naval Construction in the Admiralty. Hence it may be that it rests with the individual aeronautical engineer in industry to make the next move.

Shipbuilding & Marine Engineering in 1938

No. III

(*Continued from page 64, January 13th*)

WE complete in this article our review of the progress made in shipbuilding and marine engineering during the past year.

Coal and the British Mercantile Marine

During the year the Committee appointed by the Secretary of Mines to examine the possibility in the national interest of obtaining an increased use of coal for bunkering purposes completed its report. It pointed out that the greatest possibility of using coal instead of oil is in the case of large tramp ships and cargo liners, and passenger vessels of the intermediate type. The necessity for an all-round improvement in marine steam technique, taking into full consideration the advances recorded in land steam practice was stressed. The important factors of satisfactory bunker supplies at an economical price over a long period were referred to, and it was proposed that shipowners and colliery interests should meet and discuss these matters which were the crux of the economic problem. It was further suggested that the combined interests of shipowners, colliery owners, and shipbuilders should be enlisted to construct a small type of coal-fired steamship with engines of from 1000 to 2000 S.H.P. which should embody the most modern improvements in steam practice.

In the course of the year several ships with modern steam machinery were completed and many others were equipped with facilities for easy change from oil to coal firing.

Stoker-Fired Water-Tube Boilers

Among the ships which are equipped with high-pressure water-tube boilers and mechanical stokers may be mentioned two Japanese cargo and passenger liners which were built by the Mitsubishi Jukogyo Kaisha Company, of Nagasaki, for the service of the Osaka Shosen Kabushiki Kaisha Line. They are the steamships "Kokuryu Maru" and the "Horoku Maru," of which operating results have recently come to hand. The principal particulars of the ships are as follows:—Length overall, 453ft.; breadth, 57ft.; depth, 35ft.; draught, 21ft.; gross tonnage, 7000; S.H.P., 6500.

During overload trials of the s.s. "Kokuryu Maru" a power of 8225 S.H.P. was developed, which gave the vessel a speed of 18·581 knots, or 2·581 knots over the normal sea speed, illustrating the margin of reserve available in the stokered boiler and propelling machinery. Each of the two ships has three Mitsubishi three-drum water-tube boilers fired with Taylor marine stokers which were manufactured in England and shipped to Japan. In the accompanying engraving we illustrate one of the machines assembled at Nagasaki prior to its installation. The hotel load and auxiliaries are supplied with steam from two hand-fired, two-furnace Scotch boilers. The mechanically fired boilers burn a cheap Fushun powdered coal, while the hand-fired Scotch boilers use middle-size Takashima lump coal, this fuel being a more expensive grade, thereby serving as a further instance in which, with marine stokers, cheaper fuels can be burned more economically than is practicable with hand firing.

A special feature of the installation is the design of the coal feeds, which discharge by gravity into the coal hopper, the firing platform being on a deck above the boiler-room plates, thus eliminating the use of shovels in the stokehold itself.

Under normal operating conditions the following particulars are recorded for the mechanically fired boilers:—

Normal evaporation (per boiler)	21,100 lb. per hour
Steam pressure (at boilers)	376 lb. per sq. in.
Steam temperature (at boilers)	719 deg. Fah.
Air temperature in stoker wind box ...	318 deg. Fah.
Feed temperature	300 deg. Fah.
Air pressure in stoker wind box	1 1/2 in.
Pressure in combustion chamber... ...	Minus ·10in.
Revolutions of stoker crankshaft per hour	39·1
Coal Consumption.	
Coal consumption all purposes (12,630 B.Th.U. coal)	0·9431 lb. per S.H.P.
Coal consumption all purposes corrected to 13,500 B.Th.U. per lb. ...	0·844 lb. per S.H.P.

We are given to understand that, when the correction is made to 13,500 B.Th.U. coal, the consumption for all purposes of 0·884 lb. of coal per hour per shaft horse-power represents a record. The thermal efficiency of the whole plant on the basis of coal "as fired" is 18·9 per cent. In conclusion, the Osaka Shosen Kaisya Company reports a saving of 20 per cent. in coal consumption and 37 per cent. in the weight of boiler-room equipment by the use of high-pressure Mitsubishi three-drum water-tube boilers and Taylor marine stokers as compared with hand firing in conjunction with a low-pressure system.

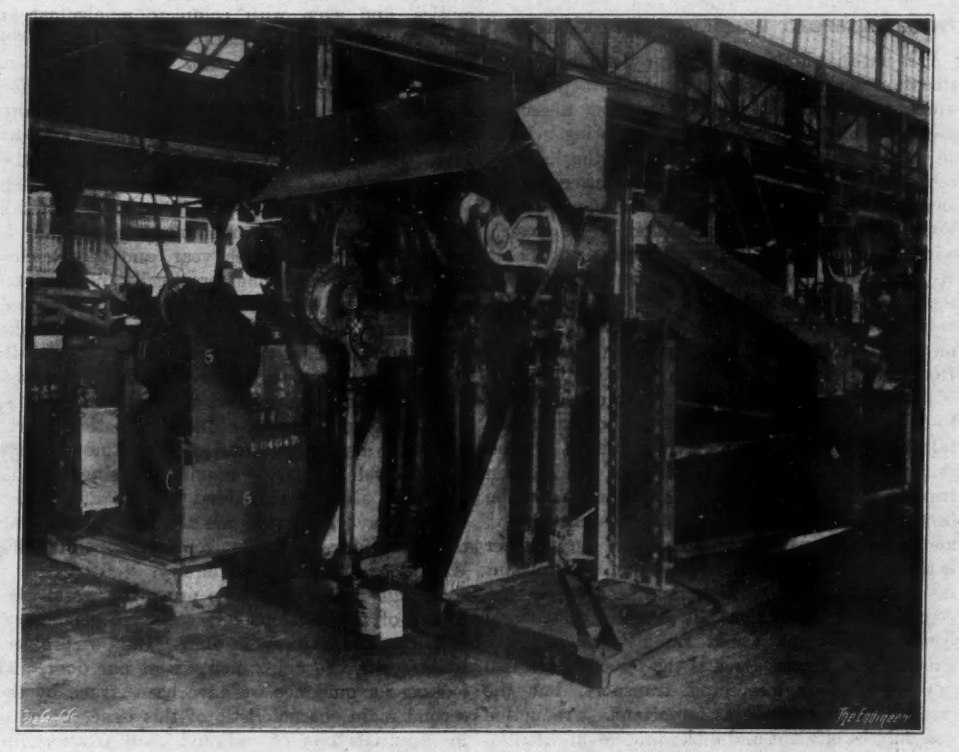
The most important British stoker-fired ship of 1938 was the turbine steamer "Amra," of the British India Steam Navigation Company, which went into service towards the end of the year, and which will be followed by a sister ship, "Aska," now building. The "Amra" was fully described in our issue of December 16th, 1938. This vessel is fitted with three standard Babcock boilers operating at 450 lb. pressure, steam temperature 750 deg. Fah., fired by Babcock-Erith retort-type stokers. The makers' trials were carried out in the North Sea on north country coal, and were in every way successful. The ship has now reached Calcutta, and is running on her Calcutta–Rangoon mail service on local Calcutta coals, and we hope to publish service results in the near future.

Another interesting ship which underwent trials in 1938 was the suction dredger "Fu Shing," built by Schichau, of Danzig, for the Whangpoo Conservancy. This ship has four standard Babcock boilers with Babcock-Erith stokers; the boilers were built by the German Babcock Company to the British Babcock Company's designs, and the stokers supplied direct from Renfrew Works.

An interesting order received by Babcocks in 1938 was for boilers and Babcock-Erith stokers for two fast Russian passenger steamers for Eastern service, the vessels themselves being built by the Netherland Shipbuilding Company, of Amsterdam.

Stoker-Fired Flue-Type Boilers

Outstanding among the ships in which mechanical stokers were applied to Scotch or flue-type marine boilers was the steamer "Man-



MARINE AUTOMATIC STOKER FOR JAPANESE SHIPS

chester Progress," which we illustrate herewith. She was built by the Blythswood Shipbuilding Company, Ltd., of Scotstoun, and her propelling machinery was supplied by David Rowan and Co., Ltd., of Glasgow. She entered the service of Manchester Liners, Ltd., in September, 1938, after completing successful official trials on the Clyde. Her principal dimensions and particulars are as follows: Length overall, 446·5ft.; Length between perpendiculars, 430ft.; breadth moulded, 57ft.; draught (loaded), 26·5ft.; deadweight, 8600 tons; displacement loaded 13,000 tons. The main propelling machinery consists of a set of single reduction gear turbines of the Parsons type developing 3800 S.H.P. at 90 r.p.m. Steam is raised in three single-ended three-flue 16ft. by 12ft. Scotch boilers. Each flue is fitted with a Bennis marine stoker and self-cleaning furnace, the stokers being arranged for preheated air from tubular air heaters. The chief details of the boilers are given below:

Generating heating surface (each boiler)	3065 square feet
Superheating surface (each boiler) ...	1340 square feet
Air heating surface (each boiler)	1310 square feet
Working pressure	225 lb. per square inch

In an accompanying engraving we show the Bennis marine stokers in the boiler-room. The following information regarding the performance of the stokers and the associated equipment was recorded on 20 per cent. overload trial and subsequently on passage from Glasgow to Manchester under normal conditions:—

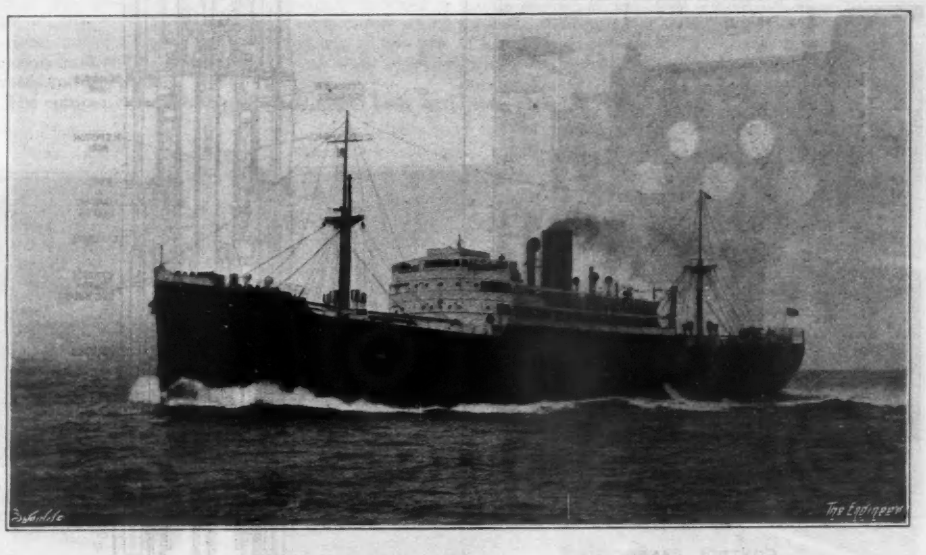
	Normal (on passage, Glasgow to Manchester).	Trial trip (approx. 20% above normal).
Total evaporation, lb. per hour ...	42,500 ...	55,580
Boiler pressure, lb. per sq. in. ...	225 ...	225
Final steam temperature leaving superheater, deg. Fah.	745 ...	778
Temperature feed water to boilers deg. Fah.	284 ...	287
CO_2 in gases after air heater, per cent.	10·75 ...	11·94
Temperature of gases after air heater, deg. Fah.	470 ...	544
Approximate thermal efficiency, per cent.	80·6 ...	78·6
Ship's speed, knots	13·73 ...	14·64

In summarising these records, it is noted that the trial trip figures listed above gave the vessel a speed of 14·64 knots, which is 1·14 knots in excess of the ship's normal speed. Under normal conditions the power required to drive the stokers and furnaces equals 4·2 kW, the number of charges of coal thrown into each furnace thirteen per minute, and the reciprocations of the furnace bars 1·4 per minute.

The control of the steam requirements are regulated by a panel adjacent to the main engine controls. We illustrate the upper half of the Bennis control panel showing the stoker starters, pilot lights, controllers, draught gauges, and CO_2 recorder. Since the regulation of the forced and induced draught fans is also in the engine-room, balanced draught being employed, the general arrangement is handy for the engineer on watch. The arrangement has been found a valuable feature when the vessel is in bad weather or when manœuvring. We also reproduce a general view of the engine-room in the "Manchester Progress," showing the close proximity of the Bennis stoker panel to other main controls.

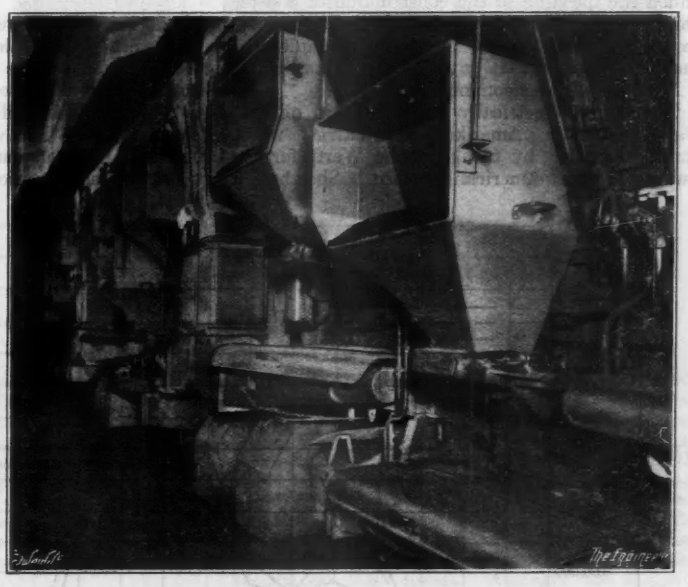
Contrary to the usual belief as regards mechanical burning of coal at sea, the ship we have described is demonstrating the fact that stokers can efficiently burn cheaper coals than are employed for hand-fired vessels. Indeed, the Superintendent Engineer, Mr. W. L. S. Moore, informs us that not only are the mechanical stokers good servants to his company, but also to all his engineers, many of whom have remarked that they would not like to revert to hand firing.

Other British ships completed during the period under review included the complete equipment of the Elder and Fyffe's Line steamships "Nicoya," "Chagres," and "Coralles," with flue-type stokers of the Babcock-Erith pattern. Each of these three ships has four four-furnace Scotch boilers, which, in service, operate on Welsh, Yorkshire, or Continental coals, according to their port of call in Europe.



S.S. "MANCHESTER PROGRESS" ON HER TRIALS

Abroad, considerable interest was taken in the design of mechanical stokers for flue-type boilers, and the North German Lloyd Company, in collaboration with the German boiler firm of L. and C. Steinmüller, of Gummersbach, conducted successful experiments with a new type of stoker having a moving slicing bar which traverses the fire bed. This stoker was described in a paper by Herr Dip.-Ing. Weber, of Düsseldorf, which was read before the Engineers' German Circle on November 7th.



ENGINE-ROOM AND STOKEHOLD OF THE S.S. "MANCHESTER PROGRESS"

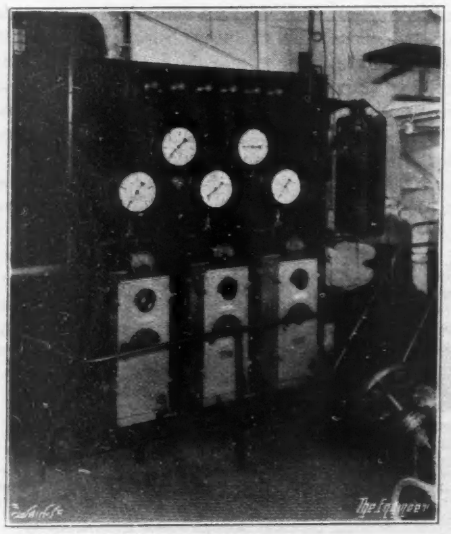
Oil-Fired Water-Tube Boilers

In our two previous articles we referred to the advanced designs of Yarrow oil-fired water-tube boilers which were adopted for the machinery of the Cunard White Star liners "Queen Elizabeth" and "Mauretania," also the P. & O. liner "Canton" and the Holland-America liner "Nieuw Amsterdam." On the Babcock side, reference may be made to the boilers of the P. & O. liner "Strathallan" and the Babcock-Johnson boilers installed in the re-engined and reboilered Union Castle liner "Windsor Castle." Similar boilers are under construction at Harland and Wolff's Belfast Yard for the Royal Mail liner "Andes." It may be recalled that the boilers of the Union Castle liners "Arundel Castle" and "Windsor Castle" are designed to operate at a working pressure of 450 lb. per square inch, and a final steam temperature of 750 deg. Fah. On the trials of these ships an overall efficiency of 88 per cent. was recorded for the boiler units. These boilers are fitted with Howden-Ljungstrom air preheaters. Babcock boilers were also installed in four of the Anglo-Saxon Petroleum Company's oil tank steamers built in British shipyards, and boilers are also being supplied for two large oil tankers for the same owners which are under construction in Holland.

Forced-Circulation Boilers

The general position with regard to the application of forced circulation boilers to marine service changed but little during the year; it is given in Dr. Mellanby's paper on "Service Results with High-pressure Boilers" read before the Institute of Marine Engineers on February 8th, 1938, and that read by Mr. R. E. Trevithick on "Forced Circulation Boilers and their Application for Marine Purposes" on December 2nd to the North-East Coast Institution of Engineers and Shipbuilders, which was partly reprinted in our issue of December 6th. During the year new ships were fitted with Velox boilers, and in Germany advances were recorded with both the Benson and La Mont-type boilers. With regard to Benson boilers the Hamburg Amerika Line took delivery before the end of the year of the cargo steamer

"Uckermark," which, in 1930, was fitted with the experimental installation of Benson boilers by Blohm and Voss, of Hamburg. The ship has now been converted to full Benson boiler operation by the installation of two further boilers, each having a designed output of 18 tons of steam per hour with a designed working pressure of 50 atmospheres, and a final steam temperature of 420 deg. Cent. Excellent results have been obtained during the year with the two ships of the German Africa Lines, the "Pretoria" and "Windhuk," which are equipped with 14,200 S.H.P. turbine machinery taking steam from two Benson boilers at a pressure of 1200 lb. per square inch. At the



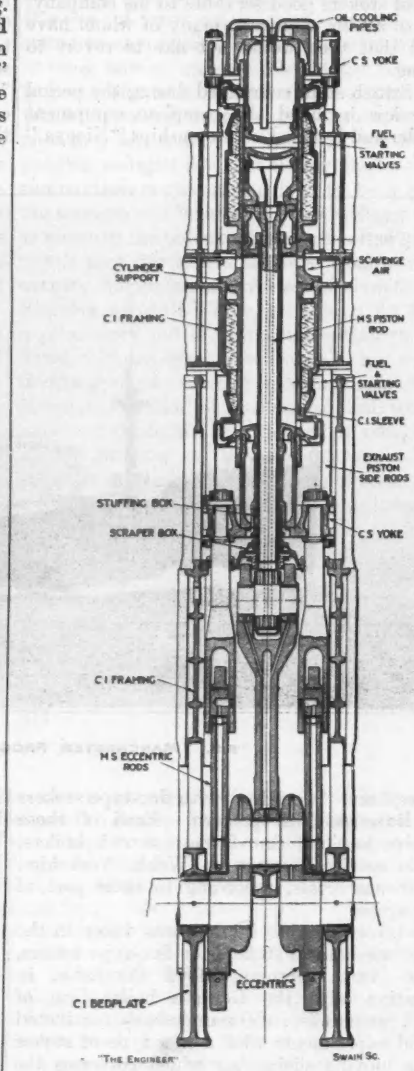
CONTROL PANEL

time of writing twelve Benson boilers are being built by Blohm and Voss at Hamburg for mercantile marine services.

Electrically-Propelled Ships

On Wednesday, July 13th, the "Normandie," the flag ship of the French Line, completed her one hundredth Transatlantic crossing. During these hundred voyages an average speed of 28·58 knots was attained; a feature of the record was the trouble-free and smooth operation of the propelling machinery, which, during the period, had required no alterations or repairs other than a slight turbine blade modification during the first few voyages. Before the year ended the question of the construction of a sister ship was raised, which, when built, will, it is expected, embody the advances in hull and machinery design that have taken place since the "Normandie" was commissioned.

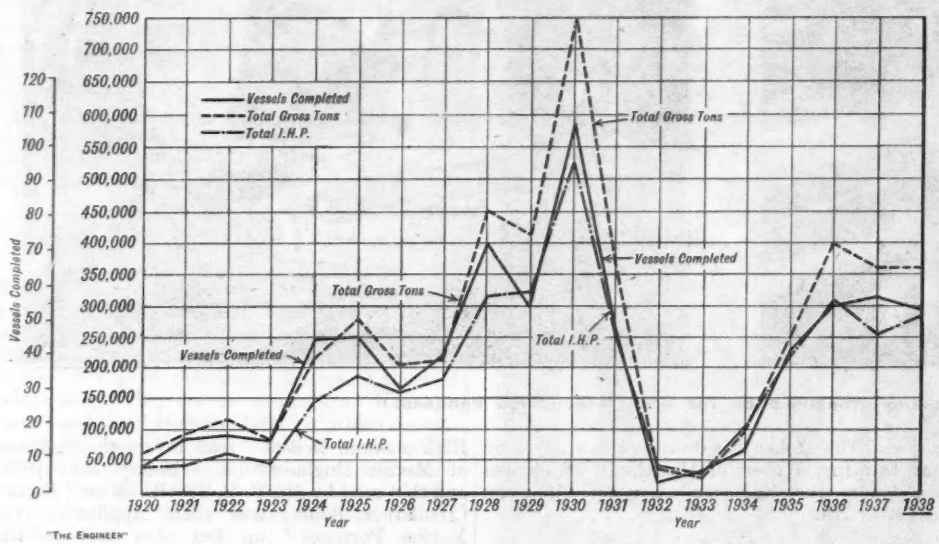
The largest electrically propelled ship of 1938 was the Hamburg Amerika Line "Patria," which was constructed by the Deutsche Werft for the owners' South American service. She has a length of about 597ft., a beam of nearly 74ft., and a depth of 32ft. to the bulkhead deck. Her measurement is 16,600 gross tons, and her electrical propelling machinery is designed to give her a service speed of about 17 knots with a maximum speed of 19 knots. There are six main generating sets each consisting of a two-stroke, single-acting, non-reversible M.A.N. oil engine of 3000 S.H.P. output, coupled to a 2140-kVA, 3300-volt alternator. Three-phase current is transmitted to two 7500 S.H.P. motors. Provision is made for interconnecting the two sets of generators, and the controls provide for operation



NEW TWO-STROKE EXPERIMENTAL ENGINE

with fuel economy over a wide range of speeds.

Amongst other electrically propelled ships which entered service during 1938 were the oil-electric Trinity House vessel "Patricia," which was described and illustrated in our issue of February 11th. She was built by Smith's Dock Company, Ltd., of South Bank, and was engined by the English Electric Company, Ltd., of Rugby. Her generating sets are twin-screw, 775 B.H.P. engines coupled to 518-kW, 550-volt D.C. generators supplying two 650 S.H.P., 200 r.p.m., propulsion motors. Her speed is about 14 knots. The new Clyde Trust vehicle ferry built by Ferguson Brothers is also of interest in this connection, as she embodies two six-cylinder Paxman oil engines driving two General Electric 200 S.H.P. motors.



BRITISH MOTORSHIP CONSTRUCTION IN 1938

Motorships and Oil Engine Progress

The Southern Railway Company took delivery of the Denny-built motor car ferry "Lymington" with Allen oil engines driving Voith-Schneider propellers. This ship was described in our issue of May 6th.

In the course of these articles we have had occasion to refer to some of the many motorships built during 1938. As the accompanying graph indicates, there were fifty-three motorships completed in British shipyards during 1938, with a total gross tonnage of about 361,000 and a total I.H.P. output of nearly 285,000. These figures show a small advance in British motorship construction compared with last year's figures, but a slight falling off in horse-power, owing partly to the non-completion of the "Dominion Monarch," which will be the highest powered motorship yet built. This ship is now ready for her preliminary trials. Great Britain again held the leading world position in motorship construction, but was almost equalled in tonnage and engine power by Germany, and was followed up by important construction programmes completed in Sweden, Holland, and Japan. The 12,500 S.H.P. Sulzer oil engines for the Nederland Steamship Company's motorship "Oranje" were described in our issue of September 30th. Another interesting new oil engine was the B. & W. single-cylinder, two-stroke, double-acting experimental engine which was constructed in close collaboration with Harland and Wolff, Ltd., and was set to work in the factory of Burmeister and Wain at Copenhagen. As a result of the builder's very successful experience with the excentric drive for the exhaust valve pistons, they have now been increased in diameter to that of the main piston, the short travel remaining as before. The new unit, a sectional view of which we have taken from Mr. C. C. Pounder's interesting paper on "Some Recent Diesel Installations and their Characteristics," read on Tuesday, January 10th, before the Institute of Marine Engineers, has a designed output of 1000 B.H.P. at 125 r.p.m. This design will be followed with interest.

Obituary

SIR ALEXANDER M. KENNEDY

THOSE of our readers who have interests in shipbuilding and marine engineering will learn with regret of the death of Sir Alexander McAusland Kennedy, which took place at his home at Gosforth on Sunday, January 15th. Few men have had a longer and more varied experience of the shipbuilding industry than Sir Alexander, who was actively associated with that industry for over sixty-one years. He was born at Dumbarton on February 18th, 1860, and served his apprenticeship in his home town with Archibald McMillan and Sons, Ltd. Whilst in the employment of that firm he became successively chief draughtsman, general manager, and director. In 1904 Sir Alexander left Dumbarton to join as managing director the firm of William Hamilton and Co., of Port Glasgow, with which firm he supervised the building of several notable ships. Early in 1919 he decided to retire from Messrs. Hamilton's and accepted the post of managing director of the Northumberland Shipbuilding Company, Ltd., of Howden-on-Tyne, a company which, under his control, rose to an important position in the shipbuilding industry. About the same time, Sir Alexander became also managing director of the Fairfield Shipbuilding and Engineering Company, Ltd., and of William Doxford and Sons, Ltd., and from 1923 he was chairman of both these firms. He retired from the chairmanship of Messrs. Doxford's in 1936, and ceased to act as managing director of the Fairfield Company early in 1937, although he continued to serve as its chairman until the end of that year.

During the war he served on many Government and industrial committees, and from 1917 to 1919 was President of the Clyde Shipbuilders' Association. In 1920 he became the President of the Shipbuilding Employers' Federation, and in 1921 received the honour of knighthood in recognition of his services to industry. Sir Alexander was a member of the Institution of Naval Architects, the Institution of Engineers and Shipbuilders in Scotland, the North-East Coast Institution of Engineers and Shipbuilders, Lloyd's Technical Committee, and of the Shipbuilding Committee of the British Standards Institution.

The Brush Coach Works

IN order to simplify the administration and avoid departmental overlapping of its widely varied interests, the Brush Electrical Engineering Company, Ltd., has recently formed its coachbuilding side into a separate company, known as Brush Coachwork, Ltd. The management of the business remains unchanged, and Mr. Hickman, the previous manager of the rolling stock department, has become general manager of the new company.

The building of coaches was begun by the Brush Electrical Engineering Company in 1889, when it started making horse-drawn buses. Since that time bodies have been built for all classes of passenger vehicles, and it is of interest to note that an all-steel body was made as far back as 1907 and exhibited at the first Commercial Motor Show held at the Olympia. Hitherto, work has been done principally in connection with large fleets, but with the formation of the new company it is intended to widen the scope of the business and cater for the owners operating small numbers of vehicles. The construction and marketing of all-metal bodies is also to be extensively developed.

The works and offices of the new company are housed in extensive buildings adjoining the Brush works at Loughborough. In a recent visit we had an opportunity of seeing the works and inspecting a large number of vehicles in their various stages of manufacture. The timber used in the construction of the composite bodies is all naturally seasoned in an extensive yard adjoining the works. It is stacked in large open-ended sheds after being cut into plank form. The bays of the timber yard are served by a rail track and there are a number of cranes to expedite handling.

From the timber yard the wood is taken to the saw mill shown in Fig. 1, where it is cut to the various shapes required. In this shop, by the use of jigs, templates, and careful machine setting, work is done to fine limits. By maintaining these limits the various parts are assembled at a later stage with little or no trouble. Each machine is served by a dust and chip-exhausting cowl, connected by pipes to a central duct which leads to the exterior of the shop. All waste material is burnt in the furnaces of the works heating system. Each bay of the shop is served by trollies on rails leading to the other departments. This saw mill is shortly to be completely modernised, and equipped with the latest types of machines.

In the composite body-building shop the framing of single and double-deck vehicles is assembled in three separate bays. The sides and ends of the bodies are assembled and then brought forward in sets to be built up together on the underframe which is mounted on a rail trolley. At the end of the production lines the bodies are fitted with their exterior panels and are glazed.

The company has developed an all-metal body and most of the parts for this type of vehicle are made in the metal fitting shop shown in Fig. 2. Adjoining this shop is another, in which all-metal parts are treated by the "Bonderizing" process for the prevention of corrosion. In the assembling of these bodies adhesive rubber tape is placed between all metal-to-metal joints in order to prevent any possibility of drumming. In addition to a 200-ton press used for forming components and various other sheet metal working machines, the shop also contains three spot-welding machines.

When the bodies have been mounted on their chassis they are passed out to the panelling and chassis mounting department, Fig. 3. Here their upper saloons, interior panels, flooring, and general fitting is carried out.

Whilst the bodies are being built, their fittings and furnishings, seats, window frames, ventilators, mouldings, &c., are being prepared in the finishing and polishing shops. After passing through the paint shop, where the priming, filling, and finishing coats are applied, the bodies pass into varnishing shops, where they receive their various fittings and are finished off ready for inspection. The general inspection of a completed bus includes a water test to ascertain its weather-resisting properties, and a tilting and weighing test to conform with Ministry of Transport regulations.

FIG. 1—SAW MILL

FIG. 2—FITTING SHOP

FIG. 3—PANELLING SHOP

FIG. 4—PAINT SHOP

Engineering Notes from China

(By our Own Correspondent)

HONG KONG

Destruction and Reconstruction

JAPAN'S first acts of war in China were to destroy or seize many of China's most advanced economic bases in the Shanghai area and North China. A few weeks ago Hankow and Canton were captured. In both cities there had been erected modern industrial plants. In Canton the Chinese destroyed by fire practically everything of value and the city is still deserted by them. But a new Canton will be built at some time. Seventy per cent. of the mechanised industries in China proper were in the Shanghai area. Many factories owned by Chinese were outside the International Settlement in what was called Greater Shanghai, an area entirely under Chinese jurisdiction. The Japanese seized, also, many factories in the Hongkew district of the International Settlement, where there were over 900 Chinese industrial establishments. There were, before the war, some 8000 factories operating in the Greater Shanghai area, but in May, 1938, only about 1800 had resumed operations. Of the 600,000 workers formerly employed in Shanghai factories, about 130,000 are said to be back at work; 90 per cent. are in Japanese factories, according to an American expert, who calculates that Chinese and foreign losses in Shanghai, during this "China Incident," have totalled 844,500,000 U.S. dollars. Amongst the factories seized are a number of Chinese cement works. One Shanghai mill had a capacity of 20,000 tons of cement a month and the Chee Hsin Cement Company, with mills in the North, had a monthly production of 30,000 tons. There will be a very great demand for cement and steel when reconstruction takes place in China.

Shipping and Docks

Many thousands of tons of scrap iron have been broken up in China by the enemy and sent to Japan. Shipbuilding yards, flour mills, soap factories, textile mills formerly owned by Chinese are at work under Japanese management. Ships valued at £4,000,000 have been lost and as many as 475 Chinese steamships, with an aggregate tonnage of 570,000, were sunk either by Japanese bombardment or in

forming a boom across the Whangpoo River. The absence of Japanese and Chinese competition for freights has benefitted European shipping lines in the Far East. There never was more activity in the shipyards in Hong Kong than at the present time. The Taikoo slips have two 10,500-ton Glen Line vessels nearing completion, and a great deal of repair work going on, so that about 4000 men are employed there. The Hong Kong and Whampoa Dock Company must have nearly as many men at work, while the Royal Naval Yard, and many other smaller concerns, are very busy. No doubt the shortage of skilled labour in Britain and the comparatively low wages in Hong Kong, where a Chinese skilled mechanic receives rather less than 14s. a week for longer hours than are permitted in England, aids the local firms. The writer employs intelligent semi-skilled Chinese labour (with some knowledge of the English language) at 6s. a week of fifty-four hours. It is this efficient labour force, available in huge numbers, that the Japanese hope to utilise, as well as the natural resources of the country.

China's strategy to avert tragedy pivots on the factors of space and time. Its objective is not victory on the field of battle, but the slow deterioration of enemy *morale*. The only two physical advantages possessed by China are the immensity of her population and the vastness of her hinterland, large areas of which are almost inaccessible for enemy forces. It is no exaggeration to state that if the full ambitions of the military leaders of the invaders are fulfilled in China they will employ the industrious, efficient, and vast labour force in China, and the natural resources of the country to build up an army and navy that will be without precedent in the history of the world. It is small wonder that those who sympathise with China hope that the nation will continue to resist until any such catastrophe is rendered impossible.

Industries in China

Before the fall of Hankow and Canton it was estimated that 30 million Chinese had moved into the interior provinces from the war areas. The outstanding features of this war have been the heroism of the Chinese common soldier and the terrible suffering which he, and millions of peasants, have undergone; their heroism has been in sharp contrast to the failure of many of the Chinese wealthy and educated classes to "do their bit" for their country. It almost makes one think that, not only "is much study a weariness to the flesh," but that concentration upon book learning is destructive of the elementary instinct of self-defence. The discussions in the columns of this journal concerning the lack of men qualified to act as managers in British industries seem to suggest that we can so over-educate our engineers that they have, as it were, had eliminated from their nature those qualities which made the British engineers of the nineteenth century famous throughout the world. It is not unfair for one who has lived for nearly thirty years in the Far East to give his impressions of the Chinese people, and he believes that, in spite of notable exceptions, it is not the craftsmen nor the peasants who have been responsible for this tragedy in China but the educated classes, who have shown very little courage and often great selfishness.

Of all types of Chinese trained abroad or in modern subjects in China the engineers have proved themselves of greater service to their country than any of the others who have had the advantage of a Western education. There have been foreign doctors at the front, and some Chinese doctors, but the demand has been far greater than the supply. Yet in the International Settlement of Shanghai and in Hong Kong hundreds of Chinese doctors are in practice. While doctors are urgently needed for the troops, engineers are required to build up new industries in the vast interior provinces where economic resistance can be carried on. Although the more advanced economic areas are in the control of the enemy, China still has enough raw materials and natural resources in the unoccupied areas to build up new industries. The co-operative system has been employed with success in agriculture. There is now a strong movement in China in favour of a great new Government-backed scheme for quickly rebuilding China's industrial productive power in the interior provinces. Upon the success or failure of that movement the fate of China very largely depends.

The Kra Canal.

No part of the world has a more romantic history than South-Eastern Asia. This tropical region includes French Indo-China, Siam, the Malaya Peninsula, a part of Burma, and numerous islands, several of which are of very large area, including Sumatra, Java, Borneo, Celebes, &c., known collectively as the Eastern Indies. Anyone who now travels, either by rail, river, road, or air over South-Eastern Asia must realise that, in spite of man's many triumphs over the forces of Nature, how puny have been the results yet achieved in that part of the world, and how tiny a scratch man's hand has so far wrought in the face of the forest and jungle. Yet every year applied science impinges upon land which for centuries lay undeveloped and which is being slowly transformed into habitable and productive areas.

The aggression of Japan in China and the flamboyant announcements made by Japanese politicians and journalists, have revived the rumours that Japan is constructing a canal through the Kra Isthmus in Siamese territory. These rumours can be dismissed, if only because of the gigantic engineering difficulties which make the project impracticable. At first glance, the scheme seems to be very attractive. If you look at the map you will see that a canal from Chunporn, on the Gulf of Siam side, to Taplee, on the Bay of Bengal, across the Kra district, would very much reduce the sea voyage from the Far East to Europe. No doubt it was this fact that made advocates of the Kra Canal project plan for such construction, some seventy-five years ago. But detailed surveys proved that unfortunately two-thirds of the distance overland is solid rock.

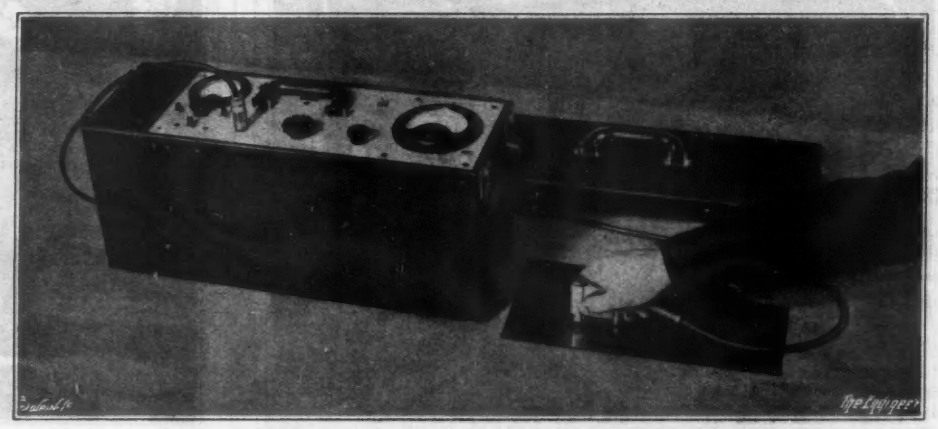
In these days of colossal engineering accomplishments, one hesitates to say that any scheme is impossible. Rough surveys and plans for the Kra Canal were projected on two occasions, viz., fifty-five and seventy-five years ago. Commander Loftus, in the Siamese Service, in 1883 accompanied a French expedition across the isthmus of Kra. His notes, with maps, &c., and a lengthy report made by Captains Fraser and Furlong to the Indian Government in 1863, are of considerable interest to engineers. They reveal the great natural obstacles in the proposed route of the canal. The mean height of the levels of the mountainous district on the Kra route is 130ft. above low-water level, or 160ft. above the bed of the canal planned seventy-five years ago. That plan assumed a transverse section, 191ft. at the top, 77ft. at the bottom, and 160ft. high, with only an angle of 20 deg. slope from the perpendicular. The total length of this portion of the suggested canal is about 20 statute miles, which means that approximately 84,000,000 cubic yards of material, say, 22,640,000 tons weight (of which about 80 per cent. is solid rock) would have to be removed. Where would this enormous bulk be deposited? The increase in the size of ocean steamers since the above calculations were made would greatly increase the excavations if they are to be accommodated. Moreover, this excavation work is only part of the scheme. There are intricate channels in the rivers which it was suggested might be made navigable for ocean steamers, and these rivers are studded with sunken rocks and shifting sands.

Very great difficulties were overcome in the construction of the Panama Canal, but they were not so great as those connected with the Kra Canal, which, if it is ever built, will almost certainly not be done by the Japanese. The Minister for Foreign Affairs in Siam recently said: "Siam will never impair her friendship with the United States, England, France, or other Powers, or jeopardise her own independence by awarding such a contract as the Kra Canal to Japan or to any other nation." It is quite obvious that the political and commercial interests of the nations mentioned above, and the Dutch, in South-Eastern Asia, are so great that they would strongly oppose any suggestion that the Japanese should construct the Kra Canal. It would divert a great deal of shipping which now passes through Singapore, and, although it would shorten the ocean route to Europe, it would give no strategic advantage to Siam that would compensate for the colossal cost of the undertaking as was the case when the United States developed the Panama Canal scheme. But although the Kra Canal scheme is impracticable, there are numerous other less expensive engineering works that could be carried out in Siam and which would be of great advantage to the people. They will probably be developed by European engineers.

A Surface Roughness Meter

AN instrument for measuring surface roughness of materials, known as the "Profilometer," and made by the Physicists Research Company of the United States, is now being marketed in this country by Gaston E. Marbaix, Ltd., 22, Carlisle Place, London, S.W.1. The surfaces of machined parts have a direct bearing on their wearing qualities and it has been found by experience that the height of surface irregularities is the most useful roughness rating. The "Profilometer" has been designed to measure a running average of the height of irregularities on a surface, irrespective of its contour.

The portable type of instrument shown below weighs about 50 lb., and fits in a case 10in. deep by 22in. long. The main instrument assembly and batteries are mounted behind a panel on which are the various meters, switches, and terminals. A small tracer head is carried in a separate section at the end of the case. In the bottom of the tracer head is a small diamond point, which is supported by pilot balls, and is rigidly coupled to a small coil situated in a magnetic field. The coil and tracer point are held in position by a small spring, and as the head is moved over a surface the point moves vertically up and down according to the roughness. This motion causes a minute electrical voltage to be produced in the coil, and these electrical impulses are amplified and measured by the instrument. The electric meter which automatically determines the average height of the irregularities is calibrated directly in inches. This meter gives a root mean square average, which is the average commonly used for oscillating quantities. For a simple curve the root mean square value is 35 per cent of the peak to valley height.



PROFILOMETER SURFACE ROUGHNESS MEASURING INSTRUMENT

The diamond point is sharp enough to bottom the irregularities, but is not loaded heavily enough to scratch or damage the specimen.

In use the tracer is moved across the surface to be tested and the meter reads a continuous running average of the height of surface irregularities. The scale is calibrated in micro-inches or millionths of an inch. It is not necessary to press the tracing head hard against the surface, as its own weight is sufficient, the readings being independent of the pressure on the specimen. A speed of trace of about 1in. per second is suitable, but the readings obtained are independent of the speed of trace over wide limits.

To adjust the tracer head for curved surfaces, the point may be raised or lowered, to ensure proper contact, by means of a small knob.

The sensitivity of the instrument can be set for full scale values of 3, 10, 30, 100, 300, and 1000 micro-inches, a range which has been found sufficient for most surfaces. The standard tracing head can be used on external surfaces larger than $\frac{1}{4}$in. diameter, on flat surfaces, and internal surfaces which will admit the tracer, or $2\frac{1}{2}$in. diameter. On smaller diameter holes it is necessary to cut the specimen to admit the tracer, and then diameters down to $\frac{1}{4}$in. can be examined.

The portable instrument contains a small non-spillable storage battery, on which it will operate for about eight hours, and dry batteries with sufficient capacity for several months.

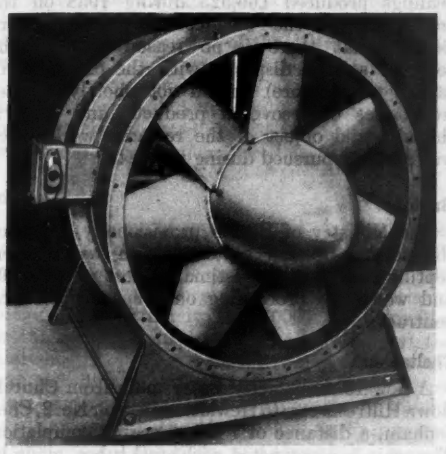
A Propeller Fan

IN the accompanying engraving is shown a recent addition to the wide range of fans made by Keith Blackman, Ltd., 27, Farringdon Avenue, London, E.C.4. Known as the "Blackman Anticlastic" propeller fan, it is intended for forcing air against moderate resistance through trunking. This work is usually done by centrifugal fans, but the straight air flow of the new fan enables the arrangement of ducting to be simpler, with consequent reduction in pressure losses and space occupied.

The impeller is keyed directly to the shaft of the motor, which is enclosed in a streamline casing and supported in the housing by four arms designed to offer little resistance to the air stream. The fan boss and end of the motor casing are also designed with a view to reducing air resistance. It is mounted in a housing of the diffuser type, and is a self-contained unit ready for fixing directly in trunking. Access to the motor is easily obtained by large doors in the

housing, and the motor connections are made through one of the hollow supporting arms. The fan is built up of mild steel and its construction permits high running speeds, it being possible, it is claimed, to run a 24in. fan at 4000 r.p.m. with perfect safety.

For general ventilation in free, or practically free, air, the company makes the same type of fan in a slightly modified form, without the diffuser housing



PROPELLER FAN

and other special features. In this design the fan and motor are mounted on the usual form of foundation ring and arms.

A Large Scrapeloader

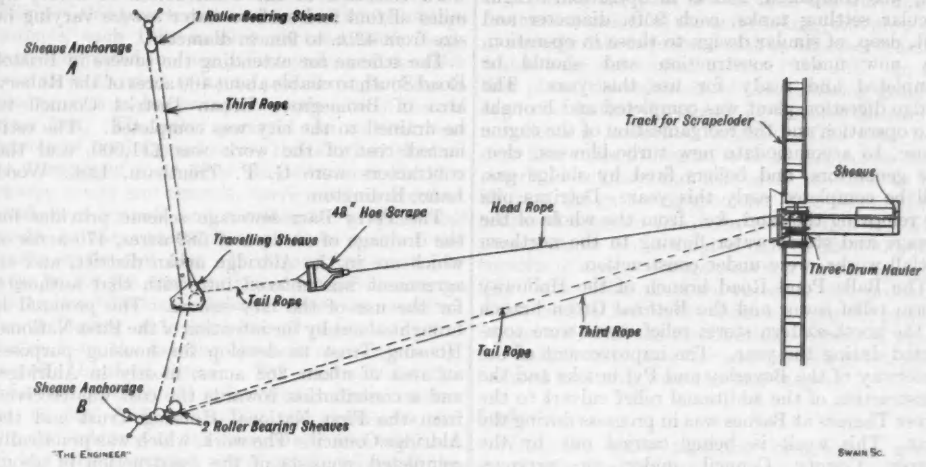
THE name "scrapeloder" is given by Holman Bros., Ltd., of Camborne, to a specially designed haulage unit, mounted on a loading slide, used to load broken rock and other loose material into trucks. "Scrapeloders" are used on tunnelling and other excavating work. An unusually large example, shown in the accompanying engravings, has recently been constructed for an overseas cement company for loading broken limestone at its quarry.

The hauler is of the makers' standard three-drum type, driven by a 50 B.H.P. electric motor, which is totally enclosed and is suitable for outdoor operation without further protection. Each drum is independently controlled by a friction band, and the third-rope drum—the use of which is described below—is fitted with a brake. The loading platform is built of steel plates, strengthened and braced by angle and channel sections. To enable it to be moved along the floor of the quarry parallel with the face, it is mounted on four 14in. diameter flanged wheels arranged for a track of 6ft. gauge. The axle-boxes—two for each wheel—are of the roller bearing type. Clamps are provided to secure the scrapeloder to the rails when scraping is in progress. The apron at the front is splayed to a width of 8ft. so that the 48in. hoe scrape will have no difficulty in entering even when it approaches from an angle. This apron is hinged and is suspended in the raised position when the platform is being moved.

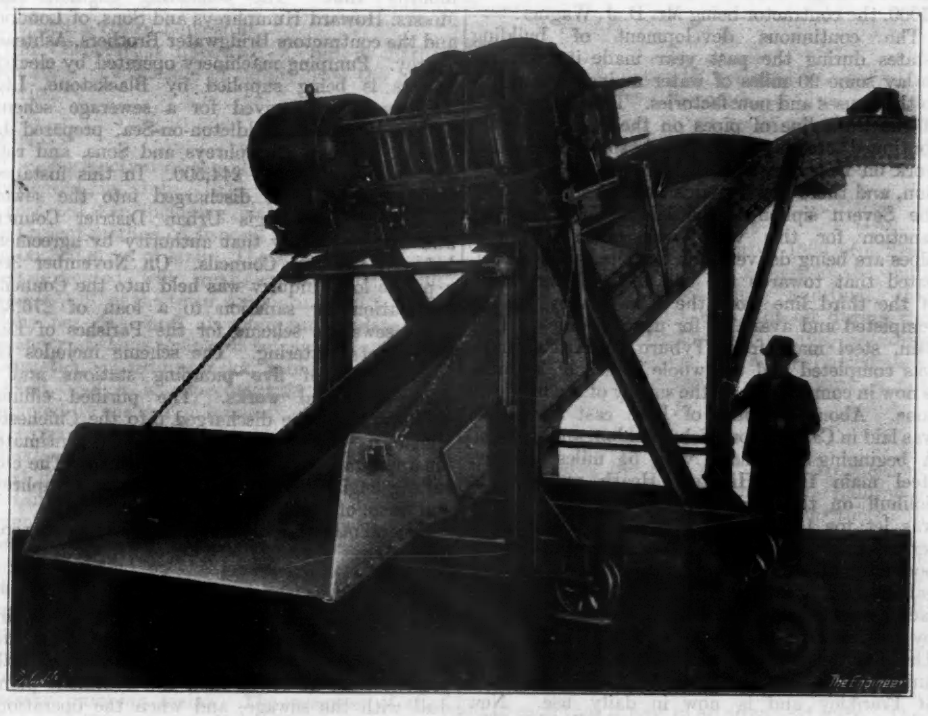
The scrapeloder has an overall length of 26ft. and is 12ft. above the rails at the highest point. The jib or rear portion permits trucks 8ft. high above rails to pass beneath and is 4ft. 6in. wide between the side plates.

The Holman three-drum scraping system is claimed to be particularly suitable for handling material from a long face, as it eliminates the delay and labour involved in constantly shifting the tail sheave. The accompanying diagram show show the scrapeloder is employed with the system. At each end of the length of face to be cleaned off an anchorage is provided. A roller-bearing sheave is secured to anchorage A and two similar sheaves to B. From the drums of the hauler three ropes, known as the "head," "tail," and "third" ropes, are led. The head rope passes over a sheave at the rear end of the platform and forward to the front of the hoe scrape, where it is secured. The tail rope is led through one of the sheaves at B, over a pulley in the travelling sheave, to the rear of the hoe scrape, to which it is attached. The third rope passes over the second sheave at B, through the travelling sheave, around the sheave at A and back to the travelling sheave, to the frame of which it is secured.

To shift the line of scraping towards A all that is necessary is to release the brake holding the third rope drum stationary and engage its clutch to wind in the rope. This action causes the travelling sheave to move towards A. When the required new position is reached the clutch is disengaged, the brake applied, and the other two drums are used to pull the scrape to and fro. To bring the travelling sheave nearer the anchorage B both the clutch and the brake of the third rope drum are disengaged and the tail rope wound in.



THE HOLMAN THREE-DRUM SCRAPING SYSTEM



THREE-DRUM ELECTRICALLY-OPERATED "SCRAPELODER"

SIXTY YEARS AGO

The Progress of Electrical Science.—The year 1878, looking back upon it from the vantage point of to-day, is not outstandingly noteworthy in the annals of physical science. Yet to those then alive and active it seemed to be marked in red letters. It began with the publication of conclusive evidence that a belief in the existence of "permanent gases" could no longer be justified. It concluded with the announcement by Lockyer of the results of his research into the nature and number of the chemical elements, a research which struck a severe blow at that other old belief, the intransmutability of matter. In electrical science the year seemed to have been particularly fruitful in progress and new discoveries. It had seen great progress in the telephone, a legacy which it had inherited from 1877, and had witnessed the discovery of the microphone. Progress, too, had been made in electric lighting, so much so that on the receipt of news from America that Edison had made a brilliant—but as yet only partially disclosed—discovery connected with the production of electric lamps, the shares of British gas companies had fallen in value from 30 to 50 per cent. In a review of electrical progress published in our issue of January 17th, 1879, we permitted ourselves some rein in forecasting the probable outcome of recent developments. Influenced by the fact that the telephone and microphone made it possible to hear sounds many miles away from their point of utterance we allowed our fancy to carry us on from the region of vibrations in the air to vibrations in the ether. Might not future discoveries, we wrote, enable us to transmit not only sound vibrations, but also those of light? Should such a supposition prove correct one of our descendants might, with the aid of an instrument resembling a phonograph, combined with some means—possibly photographic—for bottling up light, call up at pleasure any celebrity of to-day and cause him to appear and take part in a conversation. . . . It is not easy to say what precisely was in the mind of the writer of the article. He may have been dreaming of the talking cinematograph, of the telegraphic transmission of pictures, or of television. Some portions of his words seem to be applicable to each of these developments in turn. On the other hand, other portions suggest that he was contemplating a development which has not yet occurred, except in the imagination of certain authors and playrights, the recovery at will, by physical means, of the sights and sounds of past years. No doubt to him such a development would have appeared to be no more unreasonable than those which actually did arise from the discoveries of his time. The difficulties and dangers of prophesying the trend of physical discovery are great. It is easy to see in the dawning light more than will stand revealed at noon-tide. It is equally easy to overlook in the morning twilight that which will dominate the scene later. The modern student of physical and electrical science, if he were asked to assign "red letters" to any one year of the mid-Victorian era, would, in all probability, name, not 1878, but 1865, the year in which Clerk Maxwell published his electro-magnetic theory of light. Of that theory our writer never mentioned a word, although from it have arisen not only some of the developments which he seems to have foreseen, but also a complete revolution in our outlook on the whole physical universe.

GRADUATES' DANCE.—A joint dance was held on Friday last, January 13th, by the graduates of the Institution of Mechanical Engineers, the London Association of Students of the Institution of Civil Engineers, and the graduates of the Institution of Electrical Engineers, at the Victoria Halls, Bloomsbury Square, London, W.C.1. The dance, which was well attended, started at 8 p.m. and went on until 1 a.m., and was much enjoyed by all those present.

Water Supply & Sanitary Engineering in 1938

No. II

(*Continued from page 68, January 13th*)

IN what follows we give some short details of the work going forward in this country and abroad in connection with water supply and sanitary engineering during 1938.

London

The first part of the extension of the activated sludge plant at the northern outfall works, Beckton, was completed, and is in operation. Eight circular settling tanks, each 95ft. diameter and 12ft. deep, of similar design to those in operation, are now under construction and should be completed and ready for use this year. The sludge digestion plant was completed and brought into operation and the reorganisation of the engine house, to accommodate new turbo-blowers, electric generators, and boilers fired by sludge gas, will be completed early this year. Detritus pits for removing the sand, &c., from the whole of the sewage and storm water flowing to the northern outfall works were under construction.

The Balls Pond Road branch of the Holloway storm relief sewer and the Bethnal Green branch of the north-eastern storm relief sewer were completed during the year. The improvement of the waterway of the Beverley and Pyl brooks and the construction of the additional relief culvert to the River Thames at Barnes was in progress during the year. This work is being carried out by the Surrey County Council under an arrangement with the London County Council as regards the portion of the Beverley Brook vested in it. In order to deal with the increased drainage resulting from the rapid development that is taking place in the south-east corner of the county, the Eltham relief sewer, 5ft. 6in. internal diameter and about a mile in length, is being constructed of brickwork in tunnel. Construction is well advanced on the extension of the Brook Green branch of the Hammersmith storm relief sewer in Wood Lane, consisting of nearly ¾ mile of 5ft. internal diameter sewer in tunnel, part of which is in brickwork and the remainder in cast iron segments lined with concrete. For the relief of flooding in a large low-lying area in South-East London, a new storm water pumping station, discharge culvert, and relief sewer are to be built in the Rotherhithe district of the Borough of Deptford. A contract was let and work is about to commence on the construction of the discharge culvert and the first portion of the relief sewer. Tenders for the building work of the pumping station were invited. The relief sewer will be 8ft. 6in. internal diameter constructed in cast iron segments lined with concrete. For the greater part of the discharge culvert an existing outlet to the River Thames will be utilised and lined with reinforced concrete. The pumping station will be equipped in the first instance with four centrifugal pumps, each of 125 tons per minute capacity, driven by oil engines. Provision will be made for an additional two pumps to be installed in the future when the extension of the relief sewer is undertaken.

Biggleswade

Most of the machinery comprised in the contract for generators and motor-driven bore-hole centrifugal pumps placed with W. H. Allen, Sons and Co., Ltd., of Bedford, has now been manufactured, and it is expected that the four pump houses and the engine and iron-removal plant houses being constructed by Wrights (Langford), Ltd., will shortly be so far advanced as to permit of erection being commenced. The erection of the iron-removal plant manufactured by the Permutit Company, Ltd., is also expected to start shortly. These works will give the Board an additional supply of some 50,000 gallons an hour. The engineers for the scheme are Messrs. Binnie, Deacon and Gourley, and Mr. P. S. Morton is resident engineer for the machinery and building work contracts.

Birmingham

A further contract for the reconstruction of the Rea Valley main sewer from Macdonald Street to Sir Harry's Road, a distance of over 1 mile, was in hand. The new sewer is 72in. and 69in. in diameter, and constructed in brick and concrete with the exception of a short length of heading where cast iron section is being used. The estimated cost of the work is £77,000, and the contractors are Cameron and Pooley, Ltd.

The second section of the scheme for sewering the Lea Valley and Kitts Green area, which is being developed by the Corporation as an housing estate, was completed by Cameron and Pooley, Ltd., the estimated cost being £32,600. The work consisted of the construction of nearly 3½ miles of foul and surface water sewers varying in size from 42in. to 9in. in diameter.

The scheme for extending the sewers in Bristol Road South to enable about 400 acres of the Rubery area of Bromsgrove Urban District Council to be drained to the city was completed. The estimated cost of the work was £11,000, and the contractors were G. P. Trentham, Ltd., Wood Lane, Erdington.

The Perry Barr sewerage scheme provides for the drainage of an area of 589 acres, 470 acres of which are in the Aldridge urban district, and an agreement was entered into with that authority for the use of the city sewers. The proposal is brought about by the intention of the First National Housing Trust to develop for housing purposes an area of about 268 acres, mostly in Aldridge, and a contribution towards the cost was received from the First National Housing Trust and the Aldridge Council. The work, which was practically completed, consists of the construction of about 5900 yards of foul and surface water sewers varying in size from 54in. to 9in. in diameter, including a short length of 6ft. 6in. by 4ft. flat-topped culvert. The estimated cost is £44,000, and the contractors are Henry Boot and Sons, Ltd.

The Babbs Mill to Gressel Lane and Mackadown Lane outfall sewer is for the purpose of providing sewerage facilities for an industrial area at Kitts Green. The work was in hand and consists of the construction of about 3200 yards of foul and surface water sewers varying in size from 33in. to 15in. with a 7ft. by 4ft. flat-topped culvert. The estimated cost of the work is £39,000, and the contractors are Currall, Lewis and Martin, Ltd. In order to alleviate flooding the Metchley Grange valley sewer was carried out during the year and comprises the construction of 21in. to 15in. foul water sewers, and 24in. to 4ft. 6in. by 2ft. 6in. surface water culvert. The estimated cost is £7000, the contractor being Mr. D. J. Wagner.

The continuous development of building estates during the past year made it necessary to lay some 90 miles of water mains for supplies to the houses and new factories. The construction of the third line of pipes on the Elan aqueduct continued steadily throughout the year. This work on Downton siphon is approaching completion, and there now remains about 1 mile only on the Severn siphon to be laid. The necessary sanction for this work was given and the pipes are being delivered on the site. It is anticipated that towards the end of 1939 the whole of the third line from the Elan Valley will be completed and available for use if required. The 24in. steel main from Tyburn to Kitt's Green was completed and the whole length of 3½ miles is now in commission for the supply of the low-level zone. About 6½ miles of 15in. cast iron main was laid in Castle Bromwich, Sheldon, and Solihull. A beginning was made with 5½ miles of 36in. steel main from Highters Heath reservoir to Solihull on the middle-level zone. A contract was let for the construction of a new covered service reservoir at Perry Barr near the northern boundary of the city. Its capacity is 18 million gallons and it is designed to act as a balancing factor on the middle-level zone, which is supplied by gravitation from Frankley some 10 miles away. The first instalment of Primary filters in two units of 2 m.g.d. capacity was completed at Frankley and is now in daily use. New electrically driven pumps were installed at Edgbaston pumping station to deliver 3½ million gallons of water per day into Hagley Road reservoir. The old steam plant for this zone is being dismantled.

Bradford

During the year an extensive building of steel and concrete was completed to house thirty 6-ton grease vats and other plant, thus releasing the existing grease house for extension of the pressing plant from 128 to 192 units. Buildings and plant for manufacture of new products from the raw grease under patents have been successfully undertaken which will materially add to the revenue of the department. It is not usual for sewage authorities to claim much income from the disposal of polluted waters, but Bradford's business dealings produced £66,525 during 1938 on the credit side of the balance sheet. It is considered that there is no reason why all the costs of sewage disposal (with the exception of capital expenditure) should not shortly be met from sales of recovered products, and that is the aim and object of the research work which was actively pursued during the year.

Bristol

The Ministry of Health provisionally approved the scheme for an eastern storm water intercepting sewer, at an estimated cost of £400,000 and work was proceeding on preparing the first contract.

Cheltenham

A new 18in. diameter water main from Churchdown Hill reservoir to Hewletts reservoir No. 2, Cheltenham, a distance of 7 miles, neared completion. The main is constructed with steel tubes, made by Stewarts and Lloyds, Ltd., with Johnson coupling joints and the whole of the steel which would be exposed to the sub-soil is protected with bitumen. All valves and other fittings were supplied by Glenfield and Kennedy, Ltd. The contractors for laying this main are Thos. Bugbird and Son, Ltd.

Two reinforced concrete covered reservoirs were under construction on Churchdown Hill, each 196ft. 8in. by 136ft., with a capacity of 3,000,000 gallons. The contract was two-thirds completed by C. A. Horton, Ltd. The consulting engineers are Rofe and Raffety, of Westminster, and L. G. Mouchel and Partners, Ltd., of Westminster.

In addition to the above work, which is now nearing completion, a contract for pumping plant, comprising three low-lift and three high-lift horizontal centrifugal pumps, with a total capacity of 6,000,000 gallons per day, was entered into with Mather and Platt, Ltd., of Manchester.

Chichester

During the year the sewerage scheme for the Parish of Selsey, estimated to cost £72,415, was begun, and it is hoped that the work, which entails the construction of some 21,000 lineal yards of sewers, three pumping stations, and a disposal works, will be completed in about nine months' time. The consulting engineers are Messrs. Howard Humphreys and Sons, of London, and the contractors Bridgwater Brothers, Ashtead, Surrey. Pumping machinery operated by electric motors is being supplied by Blackstone, Ltd. Tenders were received for a sewerage scheme in the Parish of Middleton-on-Sea, prepared by Messrs. Howard Humphreys and Sons, and estimated to cost about £44,500. In this instance, the sewage will be discharged into the sewers of the Bognor Regis Urban District Council, and disposed of by that authority by agreement between the two Councils. On November 3rd, a public local inquiry was held into the Council's application for sanction to a loan of £76,850 for a sewerage scheme for the Parishes of East and West Wittering. The scheme includes the construction of five pumping stations and a sewage disposal works. The purified effluent will eventually be discharged into the Chichester Harbour. The Minister of Health intimated his approval of the scheme in principal. The consulting engineers are Messrs. Howard Humphreys and Sons, of London.

Several other important schemes were under consideration.

Chigwell

Considerable progress was made in the first stages of the Council's policy to centralise the purification of the sewage from the district. At the present time no fewer than six treatment plants deal with the sewage, and when the operations, which were begun during 1938, are completed, five of these plants will be replaced by a single purification works. The sixth will in due course also be superseded, but the long trunk sewer necessary to effect this cannot be justified until development of the intervening land is due to take place. Two schemes were put in hand. The more important scheme comprises a main intercepting sewer nearly 5 miles in length and varying in size from 9in. to 30in., which will collect the sewage from the

northern side of the River Roding which bisects the district. This work was nearly completed. The sewer will discharge by means of two syphons of 20in. and 18in. diameter to a new purification works which is being constructed on the south side of the River Roding. These works are designed for a daily dry-weather flow of 1,000,000 gallons, and it is anticipated that they will be in operation about the middle of this year. The estimated cost of the scheme is £108,600. The second scheme deals with an outlying portion of the district, which lies in an entirely different watershed. It comprises a system of sewers and an automatic pumping station which will deliver to an existing outfall sewer. The estimated cost of this undertaking is £8900, and it will be completed early in 1939.

Consett

A large scheme of sewerage and sewage disposal was being carried out during the year for the new Consett urban district area, comprising Consett, Benfieldside, Leadgate, and Medomsley, the scheme costing approximately £120,000. It provides for the scrapping of several small works and the enlargement of other existing works to take the increased flow of sewage. Numerous lengths of sewer are being made for the purpose of linking up all areas with the three main works situated at Westwood, Pont Burn, and Crookhall. Messrs. D. Balfour and Sons, Newcastle-on-Tyne, are the consultant engineers, and Messrs. William Birch and Sons, contractors, of York, were busily engaged with the work. It is estimated that the work will take about two years.

Corby (Northants)

The construction of the Eye Brook reservoir by direct labour was continued throughout the year, and about one-third of the embankment was completed. It will be about 1700ft. long and about 50ft. high, and will form a reservoir holding about 1540 million gallons. The joint engineers for the scheme are Messrs. Binnie, Deacon and Gourley and Messrs. Herbert Lapworth Partners, and the resident engineer is Mr. A. R. Ellison.

Coventry

Work upon the contract for sinking bore-holes at the Meriden Shafts site was completed during 1938. The works consist of two bore-holes sunk to a depth of 666ft., with a top diameter of 36in. and at the bottom 22in. Contracts were placed for the provision of machinery and the erection of the pumping station building. One bore-hole, with a top diameter of 36in. and a bottom diameter of 27in., was sunk to a depth of 524ft., and a second bore-hole reached a depth of 322ft. at the Green Lane site.

The Corporation deposited a Bill in Parliament for a new scheme of supply from the River Severn.

Darlington

The construction of the new sewage works was commenced in July, 1938, and is estimated to cost £84,000, including plant and machinery. The present method of disposal is by broad irrigation on 320 acres of land. The scheme at present being executed will treat approximately half of the D.W.F. of the town, amounting to 1,650,000 gallons per day, and at some future date the remainder of the scheme will be carried out. The construction of sedimentation tanks is now well in hand, and it is expected that they will be completed by the end of January. Some difficulty was experienced during the excavations for the foundations of the tanks owing to the water-logged nature of the site. On the north side of the tanks a deep pocket of alluvial mud was encountered overlying gravel, and it was found necessary to construct concrete piers 7ft. by 4ft. 6in., founded on the gravel under the main walls at 20ft. centres. Steel reinforcement was provided in the base of the walls between the piers. The underdrainage and lay-out of the land reserved for sludge drying is being rapidly completed, together with the installation of the necessary pumping mains. The progress of the bulk excavation is proceeding satisfactorily, some 14,000 cubic yards having been removed out of a total of 51,000.

The Derwent Valley Water Board

It is generally known that the Derwent Valley Water Board is at the present time engaged in carrying out the third instalment of the works authorised, and during the year 1938 considerable progress was made.

The principal work of the third instalment of the Derwent Valley Water Acts and Orders, 1899 to 1938, is the great Ladybower reservoir, which will have a capacity of about 5500 million gallons. This figure compares with a total capacity of the already constructed Howden and Derwent reservoirs of 4100 million gallons. The embankment forming the Ladybower reservoir is being constructed to the design and under the superintendence of Messrs. G. H. Hill and Sons (Manchester), and the work is being carried out by the contractor, Mr. Richard Baillie, of Haddington, East Lothian. The earthen embankment will be 141ft. high and 1250ft. long; a cut-off trench, with an average depth of 167ft., has been excavated along the whole length of the embankment, and the end of 1938 saw the virtual completion of the filling of this trench with concrete. Twin discharge tunnels, each 12ft. in diameter and 950ft. long, were completed in June of last year, and the river was then diverted so as to pass through them to enable work to be carried on on the site of the old river bed. The outer parts of the embankment have now been formed across the old river channel to a height of some 35ft. In addition to the discharge shafts and tunnels, there are two overflow shafts and tunnels, and considerable progress was made in the construction of these and of the works in the tail bay. In August last contracts were let for the construction of road diversions in connection with the Ladybower reservoir, as well as for the laying of a third line of pipes, 48in. diameter, from the existing Derwent reservoir to the Board's Banford filters. The contract for the construction of the 4½ miles of road diversions was let to Mr. Richard Baillie, the contractor for the embankment of the Ladybower reservoir, and he has already carried out about one-sixth of the total volume of excavation. The contract for the laying of the third line of 48in. pipes, about 5 miles, and for the alterations to existing pipe lines, was let to Lehane, Mackenzie and Shand, Ltd., of Derby. The pipes used are of cast iron and are being supplied by the Staveley Coal and Iron Company, Ltd.

The end of 1938 also saw the practical completion of the laying of 9¼ miles of 48in. diameter steel pipes forming a second line of pipes on that part of the Board's aqueduct which extends southwards from Ambergate to supply Derby and Leicester. Lehane, Mackenzie and Shand, Ltd., were the contractors for the laying of these pipes also, but the steel pipes used were manufactured by the South Durham Steel and Iron Company, Ltd. The two pipe laying contracts mentioned and the road diversions are being carried out under the direction of Mr. R. W. S. Thompson, the Engineer of the Board.

Edinburgh

A small automatically operated booster plant was installed at the Fairmilehead filter works to boost and maintain an adequate pressure to the new residential area contiguous to the Fairmilehead works:

Capacity of plant, gallons per hour	7000
Average pumping head	100ft.
Cost, including building	£1050

Following on the laying during 1936 of a 27in. diameter concrete-lined pipe alongside the built section of the Moorfoot water aqueduct, this section of the aqueduct was shut off during the greater part of the summer for repairs, including the partial reconstruction of a bridge immediately south of Gladhouse reservoir. This work is not yet completed.

Glasgow

Work during the year was limited to the construction of sewers. The first part of the Balornock sewer, 3ft. 6in. by 2ft. 4in., was constructed in brick, mostly in tunnel, at a depth of about 80ft., and a second part of similar dimensions was put in hand. Several other sewers up to 8ft. diameter in concrete segments were completed or put in hand.

Lancaster

Work on two schemes was begun during 1938, and in each case is now in an advanced state. The first scheme constitutes additional works to augment the water supply to the neighbouring borough of Morecambe and Heysham. A new 15in. diameter main, 5210 yards long, from Wyresdale Road service reservoir to Cross Hill meter house, neared completion. A further battery of four Bell's mechanical pressure filters was installed at the Langthwaite filter house, and as the final stage in this scheme an extension of the Wyresdale Road service reservoir is to be put in hand at an early date. This extension is to be carried out in reinforced concrete, and will increase the capacity of the reservoir from 1,250,000 to 3,000,000 gallons. The estimated cost of the above works is £32,550.

The second scheme is concerned with the collecting side of the undertaking, and comprises a new trunk main from the gathering grounds at Grizedale to the Langthwaite storage reservoir. This work is being carried out in 21in. diameter spun iron pipes which are supplementing a 15in. main, which was laid in 1920 as the first stage of the Lancaster Corporation Parliamentary Bill, 1918. The scheme is being carried out by contract in three sections, the total length being 9700 yards, at an estimated cost of £29,000.

The Water Committee had under consideration during the past few months the question of further extensions of the undertaking, and proposed at an early date to proceed with two further schemes which were sanctioned by the 1918 Bill. In the first place, the resources of the gathering grounds are to be further developed by the construction of a collecting main and intakes. This pipe line, over four miles in length, is to be laid across open moorland country and will cover the area to the limits of the gathering grounds. The second of the proposed schemes has been included in the five-year plan, at an estimated cost of £200,000, and consists of a new storage reservoir on the Sparrow Ghyll site. This proposed reservoir will probably mean the final link in the chain between the gathering grounds and the distribution system, of which the Langthwaite reservoir and the new trunk main referred to above were the first stages.

Leeds

With the slum clearance programme going steadily forward, and the consequent movement of population to new housing estates on the outskirts of the city, the work of the waterworks department in Leeds was mainly concerned during the year with the extension of mains; 43,000 yards of 4in. diameter and 3870 yards of 6in. diameter were laid. The pipes used were principally "spun cast" with a "neat" cement lining. Some 6500 yards of 3in. (unlined) mains were also laid principally for private supplies to works, but including some 2000 yards of cement-asbestos pipes in rural areas of direct supply. Electrically driven centrifugal pumps of 208,000 and 41,600 gallons per hour capacity respectively were installed at the Headingley and Gipsy Lane (Dewsbury Road) pumping stations.

Liverpool

In order to meet the demands of the developments in the Speke and Garston districts, it has been found necessary to provide a new service reservoir. This reservoir will be of reinforced concrete, with a capacity of approximately 3,000,000 gallons, and will be covered. The construction is being carried out by Morrison and Sons, Ltd., of Liverpool, the contract price being £16,687. Work on the site commenced in July, 1938. Excavation down to floor level was carried out, and good progress made in the concreting of foundations. Construction of the main walls was commenced. Good progress was made in the lay-out of an entirely new distribution system in connection with the development of the new industrial area and satellite town of some 5000 houses at Speke.

The installation of the second electrically driven bore-hole pump B, together with the booster attached thereto, was completed at the Mouldsworth pumping station. Since that time both the pump and booster connected therewith having been found to function quite satisfactorily, it was decided to dismantle pump A after being in operation for the past eighteen months in order to ascertain its condition and whether anything needed attention. This work was put in hand, and is proceeding at the present time. A contract was let and work was commenced on the sinking of a shaft and the driving of adits therefrom. In order to facilitate the sinking of the shaft the surrounding ground is to be frozen down to the surface of the rock, and for this purpose bore-holes are at present being sunk. The contractors for the work of sinking the shaft and the driving of adits are A. Waddington and Sons, Ltd.

Liverpool: Vyrnwy Aqueduct

The following works in connection with the third instalment of the aqueduct from Lake Vyrnwy were in progress during 1937:—

Norton-Prescot Section.—The sinking of the two shafts and driving of the connecting tunnel had been completed by the end of 1937, the lining of

the tunnel with cast iron segments being finished in January, 1938. Pipe laying in the tunnel then commenced, the joints of the 38in. steel pipes being welded by the electric arc process. The concrete lining in the north and south shafts was continued, this work being completed in May, 1938. By early June, all pipe laying had been completed and the main tested. The laying of the 40in. steel pipes, with welded joints, through the Manchester Ship Canal Subway was completed during March, 1938. The connecting main between the Ship Canal Subway and Mersey Crossing No. 2 consists of 38in. diameter steel pipes with welded joints, and, owing to the heavy traffic of the Ship Canal Railway and road, it was encased in concrete, the work being completed in May, 1938. A permanent lighting installation was fitted in the Ship Canal Subway, Mersey Crossing No. 1, and Mersey Crossing No. 2, all work being made water-tight in order that it shall not be affected even by flooding of the tunnels. Electrically driven submersible pumps were installed in the sumps of the Ship Canal Subway and Mersey Crossing No. 2. On a length of approximately 1 mile of 42in. bitumen lined and sheathed steel pipes from the north shaft of Mersey Crossing No. 2 to Sankey, including the crossing of the Sankey Canal and London, Midland and Scottish Railway, the main pipe laying had been carried out by the end of 1937, the remaining work being the laying of the pipes across the marshy ground at Cuerdley. This work was commenced during the summer of 1937 and was finally completed in March, 1938.

Oswestry-Malpas Section.—A length of 4·18 miles of 38in. bitumen-lined and sheathed steel pipes was commenced in June, 1937. The main pipe laying had been carried out by the end of January, 1938, the necessary cross connections and valves being completed shortly afterwards.

The construction of the third instalment of the Vyrnwy aqueduct was completed by July, 1938. The total cost to date is nearly £1,200,000.

Luton

Contracts for the main sewer and entirely new sewage purification works were let, and work has proceeded since May. The sewer has been designed for a population of 150,000, while the works will treat the flow from a population of 120,000, provision being made for future extensions. Further works, such as buildings and special plant, are in process of design. The whole of these works are estimated to cost upwards of £370,000. The consulting engineers are J. D. and D. M. Watson, of Westminster.

Manchester

In the Longdendale Valley steady progress was made in extending the overflows and deepening the watercourses, and work at four of the reservoirs was completed. The remaining reservoir is being dealt with and the full capacity of the series of reservoirs will be available in the coming year.

At the Davyhulme sewage works the two additional preliminary settlement tanks commenced last year were completed at a cost of £30,000. They are rectangular, and are fitted with "Mieder" scrapers. The underground pump well and the motor house for the Urmston area pumping station were completed and fitted at a cost of £6000. An additional septic tank, humus tanks, and a sludge drying area were commenced at the Baguley Sanatorium sewage works to deal with the increased population, at an estimated cost of £650.

The fifth section of the Eastern intercepting sewer of Wythenshawe main drainage, a 5ft. diameter brick sewer, was completed at a cost of £11,500. Work was commenced on a 6ft. 3in. diameter brick sewer at an average depth of 60ft. It is estimated to cost £61,200. A storm-water overflow, consisting of 18in. diameter cast iron pipes and 21in. to 30in. diameter concrete pipes was completed at a cost of £12,000. Sewers for the relief of flooding in North Manchester were commenced, varying from 9in. to 21in. diameter pipes, 2ft. 3in. cast iron pipes, and a 4ft. 3in. brick barrel sewer. The estimated cost is £24,500.

Middlesex

Ministry of Health sanction was given to the construction of a sewer to link up the existing sewage works at Hampton to the West Middlesex main drainage system. A contract was let to Wm. Moss and Sons, Ltd., and work is expected to start early in 1939, the estimated cost being £36,000.

Work on the design of the East Middlesex main drainage scheme was proceeding, and it is expected that the first contract will be let early in 1939. The scheme covers some 33 miles of main sewers and purification works for a population of 800,000. The parliamentary estimate for the work is £2,700,000, and it is hoped that the work will be completed in about six years. These schemes are being carried out to the designs and under the supervision of J. D. and D. M. Watson, of Westminster.

Oldham

Alterations and additions to the sewage purification works providing for a population of 155,000, at an estimated cost of £84,000, were finished. Work is proceeding on the design of new main sewerage, estimated to cost £75,000. The consulting engineers are J. D. and D. M. Watson, of Westminster.

Peterborough

A contract for about 14 miles of main sewers and three pumping stations was let and work is about to start. Another contract for the construction of the purification works is expected to be let early this year. The latter will comprise a complete new activated sludge plant, the power requirements being produced by sludge digestion. The estimated cost of the scheme is £229,000, and the engineers are J. D. and D. M. Watson, of Westminster.

Plymouth

Work proceeded steadily on the construction of a new sewage purification works to provide for a population of 30,000, at an estimated cost of £90,000, and it is expected that the works will be completed by midsummer. The consulting engineers are J. D. and D. M. Watson, of Westminster.

Sheffield

The new Coisley Hill sewage works were officially opened by the Minister of Health on June 28th. Four bio-aeration units were under construction at the main works of the Department, which are estimated to cost £61,500. The scheme comprises four aeration tanks, fourteen hopper-bottomed final settling tanks, four circular final settling tanks equipped with scraping mechanisms, gear, and pump-house with mechanical plant, &c. The work is well in hand and about one-third completed.

South Essex

During the past year the South Essex Waterworks Company continued the construction of works authorised by the Act of 1935. The embankment of the Abberton reservoir was raised to its full height to contain about 5000 million gallons, and the necessary certificate for the first filling of the reservoir to about half its total depth was signed by the joint engineers in September last. It is anticipated that the necessary authority for the complete filling will be published during this year. The aqueducts required to connect together the works authorised by the before-mentioned Act with those constructed under the authority of the Act of 1928 are in use and form part of the general distribution system. The filtration and treatment works, together with the necessary pumping stations at Stratford St. Mary, Layer-de-la-Haye, and Abberton were well on the way towards completion. The engineers are T. and C. Hawksley, of Westminster.

Southampton

A covered service reservoir of 1,250,000 gallons capacity, constructed at Yew Hill in the Parish of Compton, Hampshire, in connection with the high-level supply, was under construction during the year. This reservoir has walls of mass concrete with a roof of reinforced concrete supported on reinforced concrete beams and columns, and is being constructed by contract. It should be completed by the end of February next. During the present year the first instalment of the works of the River Itchen supply will be begun.

Southend-on-Sea

The Shoeburyness and Eastern Area sewerage and sewage disposal scheme, which will cost approximately £150,000, is being carried out to provide main sewers in Shoeburyness and the eastern portion of the borough, and also to receive the sewerage from Shoeburyness for treatment at the existing sewage disposal works at Prittlewell. The scheme comprises the construction of sewers up to the diameter of 36in., of which a large portion is in heading up to 60ft. or 67ft., the construction of three sewerage pumping stations and extension of the Thorpe Hall pumping station. Ness Road pumping station was completed and several miles of sewers were laid. The work is being executed to the design of and under the supervision and direction of Messrs. J. D. and D. M. Watson, Westminster. The chief contractors are John Mowlem and Co., Ltd. The estimated cost is £135,000.

Uttoxeter

New sewage disposal works were opened in October. They consist of a complete installation for the purification of the sewage by bacterial treatment and are designed to serve a population of 6800 persons, the dry weather flow being 350,000 gallons per day. The work was carried to completion under the direction of Willcox, Raikes and Marshall, of Westminster.

Wolverhampton

Two 40in. bore-holes in the Bunter Beds of the New Red Sandstone at Hilton, near Bridgnorth, were being sunk and were nearly completed to a depth of 700ft. These are the first instalment of work authorised by the Wolverhampton Corporation Act, 1936, estimated to cost £248,250. Progress was made with the reconstruction of the old Cosford waterworks, near Shifnal, at an estimated cost of £65,000. New purification plant to deal with 2,000,000 gallons per day of river water was under construction in reinforced concrete, comprising coagulation, sedimentation, rapid gravity filtration, and sterilisation processes. Old steam pumping plant was dismantled, and the existing buildings are being altered to accommodate the new electrically driven pumping plant now under manufacture, comprising six pumping sets to deal with river and well water at the rate of 4,000,000 gallons per day.

Housing development in the part of the borough draining to the Merry Hill sewage works has been, and still is, very rapid. The Minister of Health sanctioned a loan of £15,000 for the necessary extension of these works, and the constructional work is now well advanced. The present extensions will enable the works to deal with the sewage from the full development of this part of the borough. The work now in hand will be completed early in 1939, and includes alterations to the detritus tanks, conversion of covered septic tanks to open sedimentation tanks, and the construction of two new storm water tanks, four circular percolating filters and two Dortmund type humus tanks.

FOREIGN

France

Sanitary Engineering.—Continuation of work on the Paris suburban sewerage system was the only feature calling for mention in the development of sewage disposal during the year. There are other towns which have plans for improving and modernising their sewerage arrangements, but in the uncertain state of affairs that rendered it unsafe to engage in long-term contracts, little could be done. An account of progress on the Paris works was given in THE ENGINEER of October 21st. Since then preparatory work for the construction of the sewage treatment station at Achères has been interfered with by strikes, but the collapse of the labour agitation and the prospect of a more settled future lead to the hope of a steady acceleration of activity during the present year. At the Clichy settling tanks the station has been enlarged, and new plant has been put down, including three Sulzer engines, each of 450 H.P., and three Sulzer centrifugal pumps for raising the sewage water to Colombes. At Lyons there is to be an extension of mains to meet the needs of an ever-growing suburban area. There are at present nearly 180 miles of mains in three areas separated by the Rhône and Saône under conditions that at times put dangerously high loads on mains in one section when risk would be avoided by distributing the load over all three sections. This will be done by constructing a collector main around Lyons with an outlet farther down the Rhône where the sewage will be decanted before being discharged into the river.

The refuse incineration station which was installed at Saint-Ouen, just outside Paris, thirty years ago, and has been condemned as no longer efficient, is being dismantled and will be reconstructed by the Société de Traitement Industriel des Résidus Urbains. This company is responsible for the incineration of practically all the Paris refuse, for which it receives payment from the

Department of the Seine, and the Department guarantees a loan of 45 million francs which the company will raise for the reconstruction of the Saint-Ouen incineration station. The new refuse burning plant installed at Marseilles began operations early in the year. For more than twenty years Marseilles had been sending its refuse to the stony and almost waterless Plaine de Crau, at a cost which was rendered excessive by transport in lorries and the use of a narrow-gauge railway, and the expectation that some of the cost would be defrayed by the sale of refuse as manure was unfulfilled, so that the dumping of the refuse became an unsanitary nuisance. The new installation is similar to the incineration plants at other large towns, consisting of four batteries of four Heenan and Froude furnaces, with a combustion chamber for each pair of furnaces. The chambers open into a gas flue to the steam generator, which is capable of supplying 4000 kilos. of superheated steam an hour. The plant can deal with about 300 tons of refuse a day. The Marseilles refuse being mostly vegetable has a low heat value, and for that reason the usual turbo-alternators are dispensed with, the steam being distributed for domestic heating and particularly for large stores. A feature of the Marseilles refuse burning station is a reinforced concrete chimney 244ft. high.

Water Supply.—With so much work to be done for the execution of schemes for water supply, it was disappointing to find that activity was limited by difficulties that practically arrested enterprise. Without facilities for procuring capital on favourable terms most of the projected works had to be postponed. Several towns have completed plans for large-scale work which it is hoped to put in hand now that the outlook has greatly improved, and an interesting development of the rural supply programme is the grouping of communes in the valley of the River Var for the distribution of water over large areas. Where the hydro-electric supply is cheap the water is sterilised by ozone, which process is being largely extended. The usual procedure is to form local companies for the areas concerned which grant concessions for the exploitation to companies that lay down the installations and aid in financing the undertakings. Ozone plants were completed at Marseilles, Rouen, and Roubaix-Tourcoing, while at the Saint-Maur filtering station near Paris the experimental ozone plant has been replaced by one dealing with 151,000 cubic metres of water a day. The same financial reasons that prevented the carrying out of so many undertakings were responsible for the further postponement of work on the Vals de Loire aqueduct, which is to bring a million cubic metres of water a day from the aqueous sands of the Loire Valley. A company that was formed, with the Prefect of the Seine as President, to carry out the undertaking was granted authority about three years ago to raise a loan for the purpose, and the long delay in making a start has given rise to rumours of difficulties which recently caused the town of Gien, from where the aqueduct will be constructed, to petition against the abandonment of a scheme that was authorised as a work of public utility after forty years or more of investigation. It is true that danger from air attack on an exposed aqueduct must nowadays be taken into more serious consideration than formerly, but it does not mean the abandonment of an enterprise which can be protected against such danger, and is essential to the future needs of a population of 6,000,000 inhabitants in the Department of the Seine.

Rangoon Water Supply

Work proceeded actively by direct labour during the year on the construction of the 14,800 million gallons Gyobyu reservoir on the Pegu Yomas, some 620 men being employed, and the embankment is now about 11 per cent. completed. Operations in connection with the 43-mile 56in. internal diameter concrete-lined steel pipe line, to convey the water to the Corporation's existing Kokine reservoir, comprised the earthwork formation for the pipe trench and for the railway track for the transport of the pipes and the construction of the concrete pedestals on which the pipes will be supported. About 18 miles of this work was completed. A factory for the manufacture and lining of the pipes was built, and the plant was erected therein; production of the pipes recently commenced. The scheme is being carried out to the designs and under the direction of Messrs. Binnie, Deacon and Gourley, with the collaboration of Mr. A. E. Mann, M. Inst. C.E., the Engineer to the Corporation, the chief resident engineer being Mr. E. C. Steer.

The Development of High-Speed Craft*

By H. SCOTT-PAINE

No. II

(*Continued from page 70, January 13th*)

Round Bilge and Hard Chine Hulls

THE round bilge hull shell depends to a large extent for its stability upon the sheer weight of machinery, boilers, &c., and in the absence of this load the shell would of itself be unstable. This has, in my opinion, been a great deterrent to the hull designer and the engineers in reducing the weight of either steam or Diesel machinery, which I feel is unnecessarily heavy. The hard chine boat, on the contrary, is extremely stable as a shell and there is therefore every inducement to lighten continually, not only the structure of the hull itself, but everything from the machinery to the smallest fitting.

There is a further point of comparison. A destroyer or similar vessel loses stability as her speed increases, whereas the hard chine boat, if properly designed, increases in stability with increase of speed.

Stability in Rolling.—The shape of the round bilge hull allows much freer rolling than the shape of the hard chine hull. Even by adding bilge keels and similar devices to a round bilge hull it cannot be given the damping effect possessed by the chine and the flat bottom of the other hull.

If a ship were floating on the side of an immovable hill of water, gravity would force it to slide to the bottom immediately. But the side area of the ship would resist this, causing a canting action, and the top hamper of the vessel would aggravate this tendency. In reality, however, the hill of water is frequently moving itself at considerable speed, with the effect of rolling the ship first on one side and then on the other. These are primary forces which so far cannot be overcome when using the round bilge type of hull without seriously interfering with its efficiency.

Now examine the hard chine hull, (see drawing page 106). Its shell is extremely stable of itself; there is no roll or reactionary roll. Everything that it carries can be loaded with the lowest possible vertical distance from its bottom, so that machinery, fuel tanks, oil and water can all be installed at a very low level indeed. It has as shallow a draught as possible, and to all intents and purposes there is no vertical side area and therefore little side resistance to the tendency to slide down the hill of water, and hence no inclination to roll. On the contrary, when it tends to slide, the action of the "V" bottom brings it upright, in contradiction to the action of other types of ship.

Stability in Pitching Conditions.—Now let us examine the question of sea-keeping. When driving into a head sea, or with a following sea, there is, in the case of the round bilge boat at normal or slow speeds, a body of water lifting the stern above the fore end, while the head wave when reached by the bow has to pass along a considerable length of the ship to supply sufficient buoyancy to lift it. At faster speeds the hull is in a diving position much longer, owing to the difficulty of the head wave in finding sufficient area to lift the weight of the ship, augmented by increased speed and by the possible scooping of water aboard. Speeds must therefore be frequently reduced in rough weather, and when driving faster great caution must be exercised on account of the occasionally much larger sea which always prevails, and which has been the cause of some bad accidents. After decades of ship construction, steam and motorships are being built with higher bows and an extended flare in an attempt to overcome this obvious disadvantage in bow design.

What happens to the hard chine motor torpedo boats which we have been responsible for bringing into being? In a 45 m.p.h. wind and an 8ft. sea of reasonable pitch these boats can be unhesitatingly driven up to the limit of their speed, which is 40 knots, a performance which no other boat can equal, so far as I know. It should be remarked that if this size of the sea were scaled with the size of the motor torpedo boat it would produce the most severe gale conditions for, shall we say, a ship of 2000 tons.

The worst condition of sea in which I have taken out the 1935–7 design of motor torpedo boat was for Admiralty official rough weather trials, in a south-westerly gale in the Channel off the south-east of the Isle of Wight. We had official observers on board, and the Admiralty sent a destroyer leader, the "Amazon," with photographers and official observers. The conditions were severe, the average sea being 12ft. high with large seas running as high as 20ft.; with a strong wind and spring tides we easily outran the destroyer of 1350 tons. In my opinion, the destroyer would not have been able to have been driven at more than 22 knots.

I was in charge of my motor torpedo boat and, running into a head sea, I found that I could maintain a speed of 30 knots or more. But the closest attention was demanded when the top of the sea was reached, as it was possible to drive the boat right off the sea, and throttles had to be closed until the boat's attitude conformed to the sea and allowed her to be driven again, the interval actually being a matter of seconds.

The design of the fore part of the hull makes it quite impossible to dive into the sea, as in the case of the other hull, and one is able after a few minutes' practice to control the speed of contact by use of the throttles. At the moment when experiencing resistance to the forward speed the throttles should be closed; the boat will then take its bearing by the bow and the throttles may be opened again. Sight as well as feeling helps to master the technique of this. Although the boat does not dive, it can be driven fast enough into a steep short-pitched head sea to plough the sea and momentarily retard its forward speed considerably, but here again by the technique of closing and opening throttles, which I have described, continuous high speeds can be maintained. In other conditions, with the wind and sea abeam, or with seas on the quarter or astern, maximum speed can be maintained and at 10 deg. off the head sea on either hand very high speeds can be maintained without any attention or alteration to throttles. If necessary, therefore, by a series of tacks the boat can be driven very fast into the sea and wind. Had this boat been the length of the destroyer leader, without doubt it could have run at any speed to the maximum of which it was capable.

To give further proof of the remarkable stability of the motor torpedo boat hull, I may mention that I brought her beam to wind and sea and stopped her engines, when I was able to demonstrate to the naval observers that in those severe conditions the boat was extraordinarily comfortable. We could have prepared food and carried out all the normal routine of the ship; whereas if the destroyer had stopped her engines and had lain beam to sea, she would have rolled her stowed boats in the water and have been in great danger.

In my latest design of motor torpedo boat which was launched a few weeks ago, we were out on the third day of the trials of the boat in the big gale that prevented many important ships from leaving harbour and kept the "Queen Mary" at anchor off Ryde as it was impossible to dock her. We were driving the new boat at all speeds from 20 to 40 knots in all conditions of sea for three and a-half hours in the West Channel, between the mainland and the Isle of Wight. This boat possesses sea-keeping qualities hitherto unknown with this type of craft and is far in advance of the 1935–7 design. She has an improved design of bow and an entirely new underwater form of hull and can travel faster in bad weather than any other vessel yet designed or built. The draught of the hull of the original motor torpedo boat is 2ft. 11in. and of the new boat 3ft. 9in., to the underside of the propellers. The actual draughts of the hulls are 1ft. 3in. and 1ft. 7in respectively. Both these boats can be turned at full speed in either direction in a gale, and the perfection of directional stability in all conditions of running is such that the movement of the wheel is to all intents and purposes negligible.

It may therefore be claimed that our hard chine type of boat has no reactionary or pendulum roll; that it has perfect directional stability, and does not dive or pitch in any way, and because of its extremely low centre of gravity and sea kindliness, high speeds can be maintained with stability in all directions of sea.

Stability in Turning.—All ordinary forms of hull, when turning, lean outward, which is most undesirable. The type of boat with which I am dealing has, in virtue of a form of strong inward bank, an inherent directional stability when turning to either hand—that is, it leans inwards. By design the hull can be made to bank inward to any degree required; so that with rapid turning (and the motor torpedo boat can be turned at right angles to her course throughout the speed range of 20–40 knots in seven or eight seconds) the inward inclination is designed to be such that men, guns, torpedoes, &c., have practically little or no tendency to be thrown outboard. This also permits an attitude of the hull to the sea such that, while holding enough water by keel area to prevent side slipping outwards, the boat is still able to run on the top of the sea and very little loss of speed occurs; with full helm on either hand at a propeller speed of 2500 r.p.m. a drop of only 300 r.p.m. takes place.

A round bilge boat could not possibly equal this performance. If such a boat were built the length of our motor torpedo boat, with the same weight of structure and the same power and machinery, I believe it would be quite impossible to drive it at more than 20 knots with safety. Above this speed it would be impossible to steer it, and it would be directionally unstable. The fore body of the boat would be driven out of the water, the round bilge would afford

* The Eleventh Thomas Lowe Gray Lecture. The Institution of Mechanical Engineers, January 6th.

no 'thwartship support or stability, and the torque reaction of the propellers, together with the raising of the centre of gravity would roll the ship over. Actually it would be quite impossible for the propellers to work efficiently in such a design of hull, and in my opinion it would be impossible to construct a round bilge boat so as to be comparable in any way at all.

I have not the slightest hesitation, however, in claiming that there is no limit to the size of the hard chine boat, and it is, in my opinion, incorrect to say that as the size of the hull increases more power than is obtainable from the steam machinery at present used in destroyers would necessarily be required. On the other hand, I feel sure that the weight of the machinery can be reduced considerably, the weight of reduction gear dispensed with, shaft sizes considerably reduced and the speed of the propellers increased to an extent thought impossible by marine engineers and naval architects of to-day. I have no doubt that really astonishing speeds would be reached from such a development of the hard chine boat.

Construction

As I have mentioned before, lightness of construction and of machinery is of the greatest possible importance. The 1935–7 motor torpedo boat, without fuel, oil or armament, but otherwise complete, weighs approximately 12 tons; when fully laden its weight is increased to 21–22 tons, but its speed is only decreased from 40 knots to a fraction under 38 knots. This is an extraordinary achievement. Would it be possible for a destroyer or any similar ship to carry nearly its own weight in useful load with a loss of only 2 knots in 40 knots?

This light construction also permits remarkably high acceleration and deceleration—from 8 knots to 40 knots in 7½ seconds or from 40 knots to 8 knots in 3 seconds. These remarkable figures are the result of investigating every possible means of saving weight, and from brass screws and copper nails to special propeller metal we have demanded and found light-weight high-tensile materials throughout the whole of the structure of the boats.

"Perspex" has replaced glass; longitudinal members of girder construction have replaced solid planks of timber; the scientifically constructed framework, pressed and laced together, has a strength-weight ratio unapproached before except in aeroplane construction; high-tensile material has enabled the size of the wood screws, of which tens of thousands are used in a single boat, to be reduced; the propeller shafts, brackets, and rudders are constructed of special material which has reduced their weight as compared with a few years ago by 70 per cent.; tanks have been reduced in weight to 1 lb. per gallon, and since my latest design of motor torpedo boat carries approximately 7 tons of petrol, this saving is of great importance. Many designs of tank were experimented with before the perfect shape was found. In this the whole of the skin of the tank takes up its loading in tension; diaphragm action, and hence fatigue of the metal, is entirely eliminated. Close baffling eliminated severe stresses due to surges.

All deck fittings are made of salt water resisting alloy of high-tensile strength (24 tons per square inch). High-tensile steel bolts and nuts of small diameter are used throughout, as thousands of these are required in the construction of a boat. The ceaseless quest for reduction of weight has been pursued even to the extent of engaging laboratories in the search for lighter materials, of greater strength, for special purposes. Electrical fittings presented a difficult problem and were subsequently made by ourselves to our own specification. They are all water-tight, spark-tight, and fully screened for wireless telegraphy.

The weight of my latest motor torpedo boat, complete with her Rolls-Royce-Power-Merlin marine units, but unloaded, is exactly 10 lb. per horse-power.

Machinery

When I first contemplated the building of the motor torpedo boat and had roughly designed it on paper, it was immediately apparent that nothing could be done until suitable machinery had been found. We purchased aircraft engines of the water-cooled type from Germany, France, and England, and eventually decided upon the 500 H.P. Napier "Lion" aero-engine. We obtained second-hand engines from the Air Ministry, converted six ourselves, and brought them to a state of very reasonable efficiency.

We then made arrangements with the Napier Company to build a suitable engine for us, which, while having the general characteristics of the aero-engine, was considerably modified in all directions. A new crankshaft had to be made; the old airscrew reduction gear and housing were removed, involving a new upper half to the crank case; the cylinder block was completely redesigned with a new metal of thicker gauge for the water jackets; the valve gear was redesigned; the pistons were modified to allow of indefinite slow running; and the old complicated aircraft carburetter system was completely replaced by the straightforward "Amal" type of carburetter of special construction. This carburetter gave instantaneous starting and excellent fuel consumption results. A new arrangement of oil pump, scavenge pump, and oil filters was designed, and the old hand starting gear with its complications was removed from the engine. A lower compression ratio was adopted to allow of the use of a lower grade of petrol, and the whole of the carburetter and ignition controls were redesigned. Messrs. Napier also altered the design of the master connecting-rod to allow the use of steel-backed lead-bronze bearings, and at a later date screening and bonding of the whole of the ignition gear was carried out.

On our part, the ahead and astern gear, electrical starting gear, salt water pumps, petrol pumps, exhaust manifolds, &c., were built and assembled at our own works. The fresh water and oil circuits of the engine are equipped with salt water cooler. The fresh water circuit is a closed circuit with a circulating pump. Delivery is from the engine to a header tank of large capacity and then by gravity, aided by the action of the pump, through the cooler. The cooler gear is fitted with tubes as thin as possible, and great care must be taken that no leakage takes place, for any salt water entering the fresh water circuit causes rapid damage to the cylinder walls. The material of the water jackets, having a much higher resistance, hardly suffers at all. This is so important that to the daily routine of examining the oil and petrol filters must be added the testing of the fresh water for saline content.

We ran into one unsuspected engineering difficulty in the shape of torsional oscillation at an engine speed of 1800 r.p.m. It was a border-line case and had the effect of breaking a small dog coupling on an auxiliary shaft drive. Very few failures occurred, six being directly attributable to this, so that in many instances a damping device evolved by Messrs. Napier is fitted.

With the modifications outlined above, this engine fulfilled all my requirements. In less than three years engines totalling over 150,000 H.P. have been built. These are in service in many parts of the world, run by engineers quite unfamiliar with this type of machinery, without any kind of serious trouble. The engines run for 700 to 800 hours without overhaul, and this period is being raised to 1000 hours. They have, I believe, the lowest petrol and oil consumption of any marine engine of their power. The total weight of the whole engine with its gear is under 3 lb. per horse-power, and it is built to withstand the hardest treatment. Maintenance costs between overhaul periods, apart from ordinary cleaning, plug cleaning, and filter examination, are nil; valve adjustments are also unknown. Each motor torpedo boat is fitted with three of these engines. All these power units can be removed from the hull in four hours by six men and replaced in a similar time. A single engine's removal and replacement is but two hours work for two men and two boys.

Return Drive Gear-box.—This is a feature of interest in that it allows an engine to be placed behind the inboard end of the propeller shaft. When the installation of an engine behind one having a direct drive is necessary, the return drive gear-box enables all propellers to turn the same way. The 1935–37 motor torpedo boats have two wing engines driving direct and the centre engine is situated behind the two wing engines, driving forward and through the return drive gear-box. This allowed the distribution of weight required by this particular design.

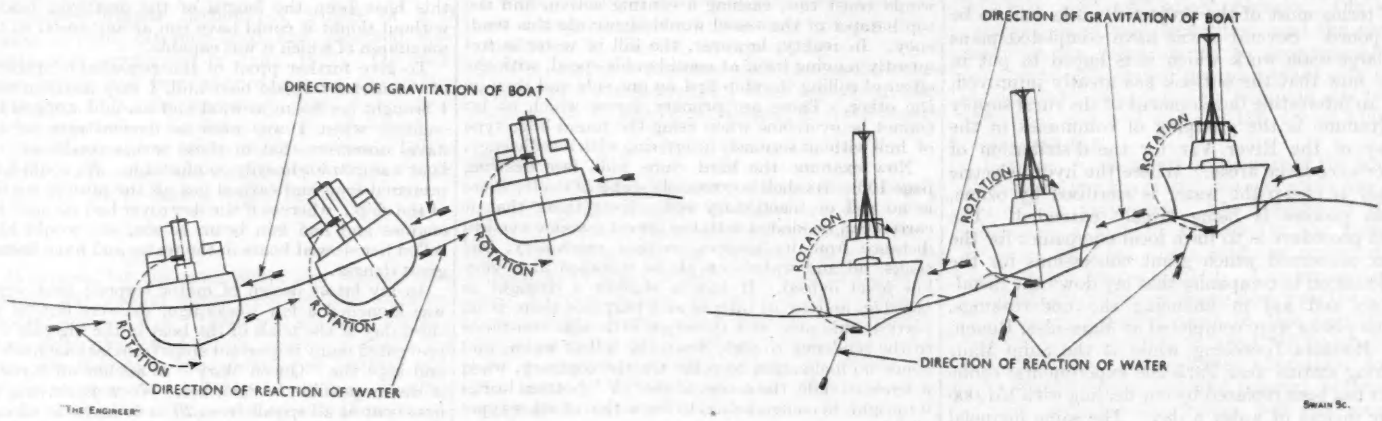
Freedom from noise in a motor torpedo boat is of the greatest importance and any kind of gear-box whine must be eliminated. I have had extensive experience with these gear-boxes in my racing boats driving at high speeds under considerable power, and we were thus able to produce a gear-box of very low weight with the simplest form of lubrication, which was noiseless throughout its speed range from 600 to 2500 r.p.m. The gear-box must be kept as free from oil as possible to prevent the generation of heat, and this was accomplished by the use of troughs, filled by the outflung oil, and returning a suitable feed to the appropriate bearings. It was a simple method, but quite foolproof, and saved the complications of feed and scavenge pumps.

Salt Water Pumps.—These were of vital importance and demanded great attention. The impossibility of lubricating the inside of the pump resulted in rapid deterioration of the spindles, spindle bearings, and the teeth of the gear wheels. A geared type of pump was the only suitable one. The usual method was to use brass or bronze and employ a driven spindle with one gear wheel driving another, the shafts being integral with the gear wheel. In sandy water, twenty hours' running would see the end of the life of a pump, as both spindles and gear wheels wore out very rapidly. We were eventually able, however, to produce an efficient pump by the following means:—The driving spindle was made of Monel metal or stainless steel. It was splined to take the gear wheel. The driving wheel was of as small a diameter as possible, the driven wheel was of larger diameter, and the driven wheel's spindle was fixed in the pump, while the wheel itself revolved on the spindle. By the usual method of grease lubrication we prolonged the life of the spindles to the overhaul period of the engine. We then experimented with material for the wheels themselves and by careful design of the teeth contours and clearances increased the life of the wheels of the pump to 100 hours in bad water conditions and 300 hours in good conditions, *i.e.*, water free from sand, &c. Renewal involved only the cost of the wheels. This was an advance on anything that we had previously been able to do.

Pipe Work.—Pipes are all made of light-gauge copper tubing of special ductility. Practically all copper tubes are dull nickel plated or chromium plated, which greatly adds to their appearance and reduces the cleaning in the engine room to a negligible amount. Generally a much higher standard of workmanship than usual was demanded, with a very rigid inspection system where bends had been hand worked. The method of attaching all pipes for oil, water, and petrol is with a rubber connection, and where lead-containing fuel is used, a suitable petrol-resisting flexible joint. Great care and attention has to be paid to the bonding of all pipes to avoid static discharge and interference with wireless telegraphy.

Engine-Room Appearance.—Generally speaking, I have all my engines and the whole of their gear white cellulose painted. This not only makes a light engine room, but is of additional practical utility in that it renders inspection an extremely simple matter. Any kind of oil or water leak or fracture of material, either in the engine or pipe work surrounding it, becomes apparent at once, and this is a practice that I am sure should be followed in all similar engineering work. It also tends to make the engine room personnel clean and proud of their engine rooms.

Propellers.—This was quite a separate problem of the greatest importance, but, of course, closely connected with the machinery itself. We had reached a normal maximum propeller speed of 3000 r.p.m., which for such a power and such a type of boat was entirely unknown. The propeller is necessarily of small diameter. It runs with a more or less normal slip of 20 per cent., and is capable of considerable towing effort. In many instances it shows a better towing effort than the older type of propeller of large diameter and slower speed, say, 300 r.p.m.



DIAGRAMS OF REACTION BETWEEN HULL AND SEA

The maximum engine speed of the Napier engine was 2500 r.p.m. The propellers fitted to these engines in the motor torpedo boats gave a very high efficiency indeed, and it is worthy of note that we have entirely done away with the old idea that in multiple-engine marine installations it is necessary to have right and left-hand engines and propellers. In boats with three and four engines all propellers turn the same way. There is no cast-off action, neither does this arrangement interfere with the directional stability of our design of boat. It reduces engine and propeller spares, and hence maintenance costs. The experimental work in connection with propellers which enabled me to obtain these satisfactory results has proved exceptionally costly.

Corrosion.—This has to all intents and purposes been defeated. The use of salt water resisting alloys, "Tungum," stainless steel, Monel metal, high-tensile bronzes, and the complete elimination of any metal that was attacked by either salt water or by salt-laden atmosphere, has reduced maintenance costs to a very small figure.

THE 21IN. MOTOR TORPEDO BOAT

In conclusion, I should like to mention my latest design of boat. The first motor torpedo boats were built as experimental and training flotillas. They were provided with 18in. torpedoes and eight Lewis guns mounted on batches of four. These guns were mounted on Scarff ring mountings and sunk into the deck, where a man was relatively secure from the boat's motion, allowing him to pay full attention to the laying and training of his gun.

My idea and desire was not to build a boat to carry 21in. torpedoes until we had at least eighteen months to two years' experience under actual service conditions of the first type of boat. During this time I had been experimenting with what I conceived to be a superior type of hard chine development, and we commenced construction of the new 21in. boat in May of last year.

This boat carries two 21in. torpedoes or four 18in. torpedoes, and carries two 20 mm. and one 25 mm. guns in weatherproof gun turrets, oil or electrically operated. It has a speed approaching 50 knots when light and over 43 knots with full war load. It incorporates many new ideas and modifications, and a most conspicuous part of the whole of the design of the boat is that it has a smaller target silhouette than the smaller 60ft. boat. It has no mast or deck fittings of any sort and is extremely difficult to see.

Its machinery consists of three 1000 H.P. Rolls-Royce-Power-Merlin engines. The Rolls-Royce engineers at Derby worked in the closest co-operation with us; we gave them a difficult set of requirements, which they carried out in what I should consider to be the shortest time on record for such work. The ahead and astern gear was built to my designs at the works of Messrs. Meadows, of Wolverhampton; this is similar in character to our gear with the Napier conversion, Messrs. Rolls-Royce assembling the gear in their experimental department at Derby. Work was commenced in the earlier part of this year and Messrs. Rolls-Royce passed the first batch of engines from their test bench in August—a remarkable achievement. These engines have been running almost daily since the ship was launched in early November. Their petrol consumption is better than that of the Napier engine, but the oil consumption is not quite so good. I should like to take this opportunity of paying tribute to the engineers of both Messrs. Napier and Messrs. Rolls-Royce, who have always been so ready to help us with their extremely wide engineering experience.

I am of the opinion that this new design may bring about a further revolution in hard chine design. We have been able to achieve a yet lighter weight, whilst carrying a much greater load at higher speeds, with much improved sea-keeping qualities, and absolute silence at 10 knots.

In fostering this new departure in design we have adopted an entirely new technique of construction, and I would add here that everything employed in the building of both hulls and machinery is of British origin and manufacture throughout.

We all hope that this design of hull and machinery may constitute an important step forward in the technical development of both British marine engineering and shipbuilding; what is perhaps of even greater consequence is that we are providing the Empire with marine defence units of extreme mobility. It is to be appreciated that these motor torepdo boats, with their shallow draught, enabling them to operate in very shallow water as well as at sea, carry the same destructive power with their torpedoes as the present-day torpedo-boat destroyer. Again, because of their shallow draught they can run over mine fields without danger, and they cannot be torpedoed. They can elude bombing and defend themselves against machine gun attack from the air owing to their great mobility, and can outrun anything in any weather conditions, whilst under cover of night they can attack with deadly results.

May I conclude by saying how much I appreciate the honour that has been paid myself and those who work with me. I should also like to make the most grateful acknowledgement to all my staff and workpeople who have worked with me; I feel I must mention the name of Mr. S. N. Barker, my friend and general manager, who has been so closely allied with all that I have attempted to do.

Engineering Precautions (Air Raid) Committee

No. II

(*Continued from page 71, January 13th*)

Quantitative Estimation.—In the preceding descriptive introduction to the subject of blast, a distinction has been drawn between the disruptive effect of the explosion, in the immediate neighbourhood of the bomb, and the distant effect that is transmitted through the air by blast, which has characteristics approximating to those of a sound wave. For the purpose of drawing a line, admittedly an arbitrary one, between the local effect and the distant effect of an explosion, it has already been suggested that there is a zone of expansion which may be taken as limited within a range to be expressed as a small multiple of the characteristic crater radius. This characteristic radius is conveniently taken from the value given in the official manual for the crater formed by a mined charge in soft and medium soils (clay, chalk, &c.). Thus R is approximately equal to $2 \cdot 3\sqrt[3]{C}$ in feet, where C is the weight of charge in lb., placed at a depth not less than R/3 nor greater than R. The relevant explosive is ammonal, which is assumed to be not dissimilar in effect from the average bomb filling. Taking a value of slightly more than twice the characteristic crater radius, the zone of expansion would be defined by a radius of $5\sqrt[3]{C}$, which for a charge of 125 lb. gives a value of 25ft. If this is the weight of filling in, say, a 500 lb. bomb, anything within a radius of 25ft. would be considered as exposed to the force of expansion, while targets outside this radius would be subject to blast.

The effect of a charge of 125 lb. at a radius of 25ft. can be appreciated by comparing it with the weight of high explosive required to demolish a 9in. brick wall at the same range. The appropriate charge, calculated for masonry buildings, &c., with good masonry walls, is officially formularised as $A\,T^2/5$, where A is the internal floor space in square feet and T is the wall thickness in feet. Taking a circular wall at 25ft. radius the weight of charge is approximately 400 T^3, giving a value of about 220 lb., for a wall thickness of 9in. Allowing for the factor of safety necessarily included in the estimation of a demolition charge, it appears that a 500 lb. bomb with a charge of 125 lb., would probably demolish a 9in. brick wall at a range of 25ft. This possibly overestimates the actual performance of such a bomb, since the demolition charge is based on interior demolition, and therefore supposes a reasonable degree of confinement.

This very rough estimate of the probable effect of a hypothetical 500 lb. bomb at a radius of 25ft. cannot be regarded as a definite criterion of the amount of protection required at this range, but it is useful as an indication of the destructive force of the bomb at the point at which the blast wave, as distinct from the expansion shock, begins to take effect.

The estimate made above of the extent of the zone of expansion has been based on the contrast between the relatively small effect of blast compared with the intense disruptive force which is exerted near the focus of the explosion. The abatement of destructive potential which occurs in a comparatively small distance indicates a very rapid decline of pressure in the immediate vicinity of the explosion. If this rate of decline were to be maintained, the effect of the explosion would very quickly die out altogether. At considerable distances, however, the pressure intensity is known to diminish with the distance in something like a linear ratio, the destructive potential being transmitted in the form of a blast wave having similar characteristics to those of a sound wave

The importance of blast, therefore, lies in the fact that it can transmit a destructive force far outside the range of the local effects of an explosion

Since blast is propagated in the form of a wave, the duration of the pressure phase is as important as its intensity At close ranges it is very difficult to make accurate measurements of any kind, although the total or combined effect of the pressure and its duration at distances from 10ft. to 15ft. and upwards can be estimated by means of disc gauges. Such gauges, which may take the form of steel cylinders the ends of which are closed by lead or copper diaphragms, are useful for comparing the forces exerted by different explosive sources, but in order to measure the actual pressure developed and to record its variation with time, some form of meter with a more rapid response is required. A convenient instrument for this purpose is the piezo-electric gauge, an electrical device in which the actual gauge, which may be described as a very sensitive electrical ear, can be placed fairly close to the explosion with a recording oscillograph in a protected position further away. Records taken at safe distances have been available for some time, and Schoszberger reproduces two oscillograms taken from the reports of the German chemico-technical research department, 1922–1927.

The curves, which are shown in Fig. 1, relate to the detonation of 1000 kilos. (1 ton) of explosive, and detail the wave forms at 500 m. and 1000 m. The maximum pressure is seen to be of very short duration, but the positive phase lasts for about one-twentieth of a second. The negative pulse is of lower intensity, but of rather longer duration.

A similar type of curve, shown in Fig. 2, has been placed at the disposal of the Committee by the Director of Building Research. This is the blast wave at a distance of 6ft. from a charge of 40 grammes, or just under $^1/_{10}$ lb., of a typical high explosive. No really effective comparison is, of course, possible between the results of detonating such widely differing quantities of explosive, having regard to the different conditions under which the records were taken. Some general conclusions may, however, be drawn.

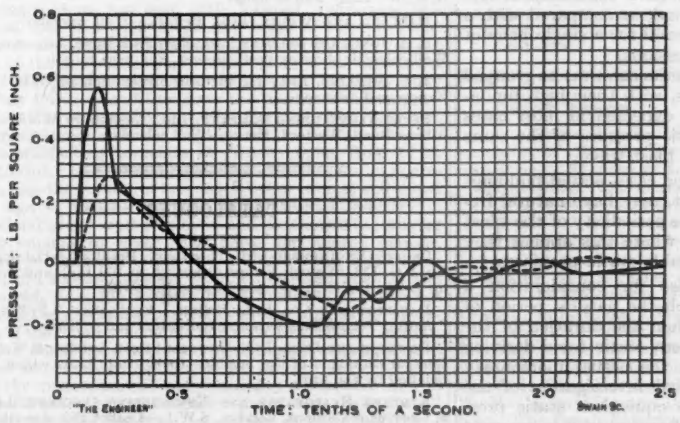


FIG. 1—*Approximate Form of Blast Wave of 1000 Kg. of High Explosive at Distances of 500 m. (Full Line) and 1000 m. (Broken Line)*

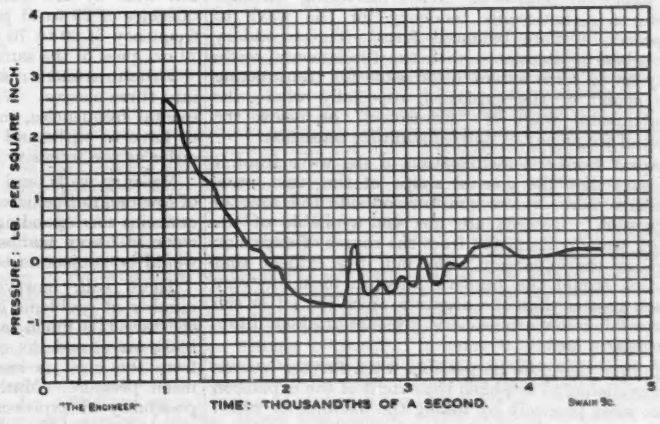


FIG. 2—*Approximate Form of Blast Wave of 0·04 Kg. of High Explosive at a Distance of 6 feet*

Using the approximate formula which has been suggested for defining the zone of concussion, the radius of this zone for the small charge would be approximately 2·2ft. Hence, the position of the recording instrument in relation to the small charge would correspond to a distance of about 70ft. for a 125 lb. charge representing a 500 lb. bomb, and about 180ft. for the 1-ton charge. These are only approximate figures because a true correspondence would require strict conditions of similarity in regard to the shape of the charge, the size and disposition of the detonator, and so on. With this reservation it appears that at these respective distances the mean pressure of the positive phase of the blast would be not less than 1·2 lb. per square inch, or about 170 lb. per square foot, even if there should be no increase of pressure with increase of charge at similar distances. This would seem to establish a lower limit for the pressures which have to be reckoned with, at the distances referred to. It has already been mentioned that at considerable distances, in relation to the size of the charge, the intensity of the blast pressure has been found to be roughly in inverse proportion to the distance from the explosion, which, incidentally, is confirmed by the two curves of Fig. 1; on this basis, the mean pressure at a distance of 500 m. from the 1-ton charge would be about 0·12 lb. per square inch instead of 0·22 lb. per square inch as actually recorded.

The duration of the blast wave for the small charge is about one four-hundredth of a second, as compared with about one-fifth of a second for the 1-ton charge. The duration of the wave is known to increase with the weight of charge, and it would not be unreasonable to take these two values as representing the limits of possible duration. It is not possible to deduce the probable duration of the blast wave for intermediate charges, but it appears likely that the limits of variation to be associated with the weights of explosive which might be used in actual bombs could be taken as one-fifth of a second and one-hundredth of a second.

A number of oscillograms of the wave form, for different weights of explosive and at different distances, are required before the whole story of blast formation and propagation can be told with reasonable certainty.

The influence of the bomb casing on the characteristics of the blast has already been mentioned, and the assumption has been made that the effect of the blast is not increased, for equal weights of explosive, by strengthening the bomb casing.

It would seem not unreasonable to go further and to presume that the effect of increasing the casing strength or thickness is to diminish the force of the blast for a given weight of explosive. It does not appear to have been established with any certainty whether or not the duration of the blast is modified by the strength of the casing; but probably the effect is a slight reduction in the time period.

A minimum thickness of casing is necessary to ensure complete detonation of the filling, since the types of high explosives which will detonate completely without confinement are either very sensitive or otherwise unsuitable for bomb fillings.

The effect of lightening the casing is at once to increase the weight of explosive which can be used in a bomb of given weight and to increase the blast effect per pound of explosive detonated. The estimation of a possible minimum thickness is therefore of some importance. Justrow mentions a charge/weight ratio of 40 to 70 per cent. and states that the largest bomb used during the war was the German 1-ton bomb containing two-thirds of a ton of explosive. It is therefore by no means unreasonable to consider the possibility of a ton of high explosive being contained in a casing about 5 cwt. or 6 cwt. in weight. Such a bomb, which might be described as a 3000 lb. light-case bomb, would develop a blast wave similar to that defined by the curves of Fig. 1.

The three curves of Figs. 1 and 2 shows a general similarity of form and balance as between the positive and negative phases. The rise to maximum pressure, which gives an almost vertical wave front on Fig. 2, becomes less steep as the distance from the source of explosion increases. With increasing distance there is a noticeable tendency for the wave to approach a more balanced form. The secondary disturbances associated with the fundamental wave may be to some extent responsible for transmitting the sound of the explosion, especially where the fundamental wave is "infrasonic," or below the limit of frequency of normal auditory sensation.

Apart from the modification of the wave front it appears that the general shape of the blast wave remains more or less constant outside the zone of expansion. Records are not yet available of the shock wave transmitted from the source of explosion through the expansion zone, but it is evident that in this region the positive pressure must be very much greater than the negative, since the latter can never fall below atmospheric pressure or about 14 lb. per square inch.

It may therefore be possible when further records are available, to establish the extent of the expansion zone more precisely by taking the distance at which the pressure pulse begins to assume the appearance of the blast wave of Fig. 2. In this figure, the maximum positive and negative pressures are considerably below atmospheric pressure, and it appears that at the distance for which this wave form was recorded, namely, 6ft., the blast wave is already well established. A similar form of curve might be anticipated up to within about 2ft. of the charge, if not closer, without the pressure intensity rising above 1 atmosphere. It follows, therefore, that the radius of the zone of expansion is in all probability no greater than the value previously estimated from empirical considerations.

Outside the radius of the zone of expansion the blast may be expected to be capable of representation by curves of wave form similar to those of Figs. 1 and 2. A phase of positive pressure is succeeded by a negative one, each phase having approximately the same pressure-time integral. Subsequent to the negative phase there is a small decaying oscillation, but it is thought that this oscillation is in general too small to cause any structural damage, and that from the structural standpoint any damage will be caused by the initial positive and negative phases of the blast wave.

The blast effect on a target might be described as a sudden push followed at a short interval of time by a sudden pull. If the duration of the push is sufficiently long the vibration set up in the target may be such that when the following pull arrives the target is already moving in sympathy with it and the effect of the pull is thereby enhanced. On the other hand if the duration of the push is relatively short, there will be no such synchronisation and the effects of the push and pull may tend to cancel one another and have only a resultant small effect on the target. The factor which determines which of the foregoing effects will actually occur is the ratio of the duration of the blast—that is, duration of initial positive and negative phases—to the natural period of vibration of the target. Expressed in terms of frequency, this factor is the product of the blast duration and the natural frequency of the target.

When this product is small a partial cancellation of the effects of the positive and negative phases will occur and the net effect will be equivalent to a static pressure much smaller than the maximum pressure in the blast wave. On the other hand, when this product is comparable with or greater than unity synchronisation may occur, and the target will be subjected to an equivalent static pressure of the same order as or greater than the maximum pressure in the blast wave. Since the product increases as the natural frequency of the target increases, it is thus seen that targets of higher frequency will in general be more easily ruptured by blast than those of lower frequency, provided, of course, that the targets are of comparable static strength.

In view of the possibility of a wide variation in the duration of the blast wave (see Figs. 1 and 2), the exact determination of the natural frequencies of particular targets is unnecessary; it is sufficient to know the approximate limits within which they might lie. In this connection the following results are of interest.

Considering first the structure as a whole, a survey of 212 buildings undertaken in California in 1934–35 showed that for buildings of height varying from 25ft. to 409ft., the fundamental frequency varied from ten per second to less than one per second, decreasing in general as height increased.

Turning to the consideration of wall panels as units of a structure, a few exploratory measurements, carried out at the Building Research Station, on brick masonry walls of thicknesses varying from 13½in. to 4½in., showed fundamental frequencies ranging from 45 to 21 per second. These frequencies, however, were determined for vibrations of very small amplitude, and it is possible that for the much larger amplitudes necessary for anything approaching failure the effective elasticity of the masonry and consequently the fundamental frequency of the panel would be considerably reduced.

In the case of windows, measurements on a pane 2ft. square of 21 oz. glass in a normal type of wooden frame gave a fundamental frequency of 58 per second. The frequency of leaded lattice windows has also been investigated and measurements on such windows, 2ft. wide by 2ft. 6in. high, gave fundamental frequencies of 25 to 31 per second, as compared with a frequency of 60 to 70 per second for a single pane of 21 oz. glass of the same dimensions.

Structures and structural units can thus be grouped into three classes. Windows, with their high fundamental frequencies, may be expected in most cases to have to withstand a static pressure of the same order as the intensity of the blast wave.

Masonry walls, and in some cases actual buildings of low or intermediate height, may have natural frequencies corresponding to the periodicity of the blast wave of heavy bombs, and where this applies they would be subject to comparable static pressures.

There will, however, arise for consideration a number of problems in which the natural period of the target is much larger than the duration of the blast wave, and the equivalent static force deriving from the blast is less than the actual momentary mean pressure. Mathematical investigation of the possibility of expressing the equivalent static pressure in terms of the relevant frequencies is in progress and has already reached an advanced stage. It is expected that the results will be available when they have been corroborated by experimental trials.

The influence of the natural frequency of possible targets has been referred to at some length, because targets of higher frequency will require a higher strength to resist blast than those of lower frequency. This is of particular importance in the case of panels and diaphragms. It must, however, be understood that resistance cannot be provided from considerations of frequency alone, irrespective of strength. On the other hand, if a target is strong enough to withstand a static pressure comparable with, but not less than, the momentary maximum intensity of the blast, the question of frequency is of no importance.

Investigations are being undertaken on the possibility of protecting windows and glazing by shutters, resilient mountings, and other devices.

A problem of some importance is that of the possible formation of blast waves inside a shelter due to an external explosion. If the wave is transmitted through the wall and re-formed without appreciable absorption, the shelter may not afford adequate protection against blast. The form of the shelter, as well as the construction of the walls, may affect the development of an internal blast wave, and investigations are now being undertaken on both these aspects of the problem.

Summary.—The main points of the discussion in Sections 1 and 2 may be summarised briefly as under, although it must be understood that any conclusions reached are not to be taken as final, since the Committee's investigations have not yet been completed:—(1) Blast is a non-translational wave of shock that is transmitted through the air to considerable distances from an exploding bomb. (2) Blast must be distinguished from the direct effect of the expanding gases, which involve pressures of much higher intensity and of different character, but effective only at short distances from the bomb. (3) A zone of expansion probably extends to a distance of about 25ft. for a charge which may be taken as representing a 500 lb. bomb, and to a distance of about 65ft. for a charge of 1 ton of high explosive, representing a 3000 lb. bomb. (4) In the blast wave a phase of positive pressure is followed by a phase of negative pressure; the combined duration of the phases may range from about a hundredth of a second to a fifth of a second, according to the weight of the bomb. (5) The mean pressure in each phase of the blast wave is approximately in direct proportion to the reciprocal of the distance. (6) For targets of comparable static strength, those of higher frequency will in general be more easily ruptured by blast than those of lower frequency. (7) Of possible targets, windows may be subject to an equivalent static pressure of the same order as the momentary maximum intensity of blast, whilst walls and buildings may be subject to similar equivalent pressures if exposed to very heavy bombs.

Investigations on the following points bearing on the problem of blast are now in progress:—(*a*) The determination of the equivalent static pressure of the blast for different classes of targets. (*b*) Protective devices applicable to windows and glazing. (*c*) The magnitude of the pressure developed inside a shelter due to an external explosion.

LAUNCHES AND TRIAL TRIPS

KARS, motorship; built by Blytheswood Shipbuilding Company, Ltd., to the order of Western Oil Shipping Company, Ltd.; dimensions, length 490ft., breadth 63ft. 6in., depth 34ft., deadweight 13,500 tons. Engines, eight-cylinder, four-stroke, single-acting, cylinders 650 mm. diameter by 1400 mm. stroke; constructed by John G. Kincaid and Co., Ltd. Launch, December 22nd.

HOPERANGE, motorship; built by Swan, Hunter and Wigham Richardson, Ltd., to the order of Hopemount Shipping Company, Ltd.; dimensions, length 412ft. 3in., breadth 57ft. 3in., depth 38ft. Engines, reversible opposed-piston, two-stroke, airless injection. Launch, January 6th.

CALENDARS, DIARIES, &c.

COX AND DANKS, Ltd., Scapa House, Park Royal Road, N.W.10.—Daily wall calendar.

HARLAND AND WOLFF, Ltd., Belfast.—Wall calendar.

A. A. JONES AND SHIPMAN, Ltd., East Park Road, Leicester.—Wall calendar showing past, present, and next month.

J. F. MELLING, Ltd., 11, Victoria Street, London, S.W.1.—Krupp wall calendar.

PETRO-FLEX TUBING COMPANY. Ltd., Cassiobury Works St. Albans Road, Watford, Herts.—Wall calendar.

CATALOGUES

CROFTS (ENGINEERS), Ltd., Thornbury, Bradford.—Catalogue No. S.G. 138, of stock V-rope drives up to 100 H.P. and ratios up to 8 to 1, and the accessories used therewith.

DAVIDSON AND CO., Ltd., Belfast.—Publication S.F. 283 on "Aeroto" screw fans for mine ventilation and collieries.

DOWDING AND DOLL, Ltd., Greycoat Street, London, S.W.1.—General catalogue of the machine tools of all kinds which are handled by the firm.

KESTNER EVAPORATOR AND ENGINEERING COMPANY, Ltd., 5, Grosvenor Gardens, London, S.W.1.—Leaflet 259, describing high-vacuum, multi-circulation evaporators for sensitive liquors, and leaflet 256 on the firm's mechanical paddle mixer.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer. A comprehensive list of the prices of materials mentioned below will be found on the next page.

The Indian Steel Trade

Although the Indian market is not of so much importance to British iron and steel makers as formerly owing to the development of the Indian production, the position ruling in that country is still of considerable interest. The "Conditions and Prospects of United Kingdom Trade in India," published by the Department of Overseas Trade (H.M. Stationery Office, 4s. 6d. net), gives a comprehensive review of the iron and steel markets during 1937–38. It points out that whilst recently there has been a modest increase in imports, the figures are well below those of 1935–36. The market was further restricted by the increase in the output of finished steel by the Tata Iron and Steel Company from 646,000 tons in 1935–36 to 660,000 in 1937–38, to which must be added the production (unknown) of several re-rolling mills which use imported and Tata billets and other semis. The high prices which ruled until the end of 1937 also had the effect of checking the demand. There is no reason to suppose that the continuous decline in the imports from 1,197,000 tons in 1927–28 to 372,000 tons in 1937–38 is likely to be checked. The rapid expansions at the Tata works and the output of the Steel Corporation of Bengal which should be available at the end of 1940 must inevitably result in a contraction in the Indian market for overseas steel to a few specialties and to those sections which the Indian works do not find it economic or convenient to roll. The prices of Tata steel, which have governed the market rates, ruled high until the end of 1937, when they were sharply reduced, notably in the case of galvanised sheets in order to keep the mills in full production and to check the decline in consumption. British exports are governed by the agreement of 1936 between the British Iron and Steel Federation and the International Steel Cartel, and based upon the exports during the year 1934. British imports in 1937–38 slightly increased in almost every case, and notably in steel bars, hoops, and strip. The German share of the tube trade expanded and Belgium sent a much heavier tonnage of steel bars; but the Japanese imports of galvanised sheets were appreciably lower in quantity, although they rose in value. Notwithstanding increases in the output of steel bars from the Indian works in 1937–38, the total imports rose from 27,515 tons to 51,229 tons, and the British share advanced from 14,191 tons to 19,156 tons, that of Belgium from 5874 tons to 12,036 tons, and of Luxemburg from 1567 tons to 9682 tons. Imports of beams, channels, pillars, girders, and bridgework rose slightly from 24,876 tons to 26,378 tons. The British share, however, increased from 14,736 tons to 17,800 tons, and the imports from Germany from 2876 tons to 3887 tons. Belgian imports dropped from 3965 tons to 3228 tons. Owing to the increase in the domestic production of the Tata Company, the imports of galvanised sheets fell from 64,599 tons to 42,800 tons, the British share falling from 40,582 tons to 25,691 tons, and that of Belgium from 7030 tons to 4865 tons. Imports of tinplates advanced from 1422 tons to 7450 tons, Great Britain's total rising to 4875 tons from 1303 tons.

The Pig Iron Market

The demand for pig iron has failed to fulfil the promise of development with which it entered the New Year. Following the reduction in the price of foundry iron, there was a fair amount of buying and a considerable volume of inquiry. This potential movement, however, has not materialised and apparently consumers are returning to the practice they pursued throughout the last quarter of 1938 and buying in small parcels for early delivery. This is rather surprising, since it is known that a large number of consumers have very little stock, and it was expected that they would take advantage of the lower prices to replenish their reserves. It is probable that they are guided to a large extent in their present policy by a lack of confidence as to the demand for their own products. So far as the light castings industry is concerned, which is the largest user of foundry iron, the outlook is far from satisfactory. Not only have the requirements of the building trade declined considerably during the past few weeks, but the competition of pressed steel and other substitutes has to be reckoned with. On the North-East Coast the output is still restricted, but is sufficient to meet the requirements of the consuming trade. No foreign pig iron is now being imported, and the view is held that there will be a gradual expansion in the demand for Cleveland qualities. The makers have disposed of a considerable proportion of the stocks in their hands and, given a moderate increase in the demand, it will probably be necessary to augment production. In the Midlands there has been little forward contracting this month and it is understood that some of the important buyers have sufficient reserves to enable them to remain out of the market for some time. Even those consumers who have liquidated their stocks appear to be in no hurry to buy forward, and this gives the market a dull appearance. The demand for low-phosphoric pig iron, however, is maintained and the engineering trades continue to take satisfactory tonnages at prices ranging from £5 5s. to £6 d/d. In Scotland eight blast-furnaces are in operation, but the volume of business is below normal and shows no sign of expansion. The light castings industry in Scotland is not well employed and consumers are buying only enough to cover their needs for limited periods. Offers of Continental pig iron are still being received at 89s., d/d Falkirk, against 99s. for Cleveland quality, and 105s. 6d. f.o.t. for Scottish No. 3 foundry. There is not much, if any, business passing in foreign iron, as the operation of the rebate scheme is a barrier to this class of business. In the hematite market the position has improved as a result of increased specifications against old contracts, but the makers are still carrying heavy stocks and there is little likelihood of any increase in production. Only a small export business has been transacted as the quotation of £5 15s. f.o.b. for No. 1 is too high to compete with foreign iron in overseas markets.

Iron and Steel Imports.

The following figures, taken from the Board of Trade Returns for December, show that imports of iron and steel and manufactures thereof declined to 52,299 tons from 65,862 tons in the previous month, and the value to £748,990 from £844,781. The total for the year indicates a fall to 1,340,735 tons, valued at £14,504,981, from the 1937 figure of 2,033,103 tons, valued at £19,805,244. Only the figures for the most important countries are given:—

	1938. Total. Tons.	1938. Nov. Tons.	1938. Dec. Tons.
Pig iron: Total	395,151	11,569	4,790
British India	155,653	3,697	1,036
Foreign countries	231,365	7,872	3,754
Ferro-alloys	47,606	3,386	3,713
Blooms, billets, and slabs:			
Total	314,989	12,551	7,758
British countries	59,462	3,860	—
Sweden	1,104	69	41
Germany	27,569	134	597
Belgium	55,417	4,791	1,907
France	101,188	3,235	4,951
Other foreign countries	70,249	462	262
Sheet bars	33,606	3,451	957
Wire rods	60,021	5,868	2,797
Other bars and rods	102,919	5,642	4,771
Angles, shapes, and sections	44,958	2,325	1,842
Girders, beams, joists, &c.:			
Total	60,134	2,716	1,581
Belgium	5,493	379	222
France	38,191	1,697	857
Other foreign countries	14,534	622	502
Plates and sheets (not coated)	68,009	4,567	4,579
Wrought tubes	22,880	1,323	1,792
Railway material	20,458	618	1,938
Bolts, nuts, and metal screws	7,109	342	279
Total from countries:			
British India	155,664	3,697	1,036
Canada	117,051	8,907	2,128
Germany	94,685	3,793	5,131
Sweden	89,804	7,758	6,942
Holland	32,583	345	328
Belgium	273,586	22,369	15,237
Luxemburg	58,570	2,980	2,613
France	257,304	7,983	9,704
Czecho-Slovakia	12,367	666	677
United States	200,671	4,558	5,701
Total imports, iron and steel	1,340,735	65,862	52,299

Iron and Steel Exports.

The exports of iron and steel and manufactures thereof in December, according to the Board of Trade Returns, fell to 162,040 tons, valued at £3,390,518, compared with 181,228 tons, valued at £3,663,413, in November. The total exports for 1938 are given as 1,917,639 tons, valued at £41,598,968, against 2,574,079 tons, valued at £48,370,349, in the previous year. The following are details of the principal exports:—

	1938. Total. Tons.	1938. Nov. Tons.	1938. Dec. Tons.
Pig iron: Total	94,012	15,914	13,208
Forge and foundry	44,375	4,002	4,005
Acid	25,690	1,035	505
Basic	23,947	10,877	8,698
Ferro-alloys	6,787	171	222
Sheet bars, bright steel bars, and wire rods	22,162	1,400	1,264
Bars and rods, other kinds	102,074	7,931	6,756
Angles, shapes, and sections	67,319	5,372	4,748
Girders, beams, joists, &c.	33,525	3,342	1,457
Hoop and strip	37,408	2,836	2,864
Plates and sheets, ⅛in. and over: Total	131,052	8,326	8,220
South Africa	7,551	165	467
British India	16,926	2,075	1,005
Australia	7,551	81	279
Canada	1,966	145	2
Other British countries	30,085	1,767	1,440
Denmark	38,611	2,838	3,001
Holland	10,633	126	410
Plates and sheets under ⅛in.:			
Total	63,516	6,287	4,664
British India	4,550	593	576
Australia	16,398	423	288
Canada	5,097	697	33
Mexico	1,880	—	—
Argentine Republic	13,113	1,755	2,602
Galvanised sheets	147,332	19,177	13,870
Tinned plates	319,403	28,156	27,199
Tubes, pipes, and fittings: Cast:			
Up to 6in. diameter	48,985	4,848	3,147
Over 6in. diameter	42,946	3,595	3,032
Wrought	220,011	19,829	22,975
Railway material:			
Steel rails, new	105,999	11,600	8,679
Sleepers, fish-plates, and sole-plates	25,618	2,309	716
Total all iron and steel	1,917,639	181,228	162,040

Current Business

James Booth (1915), Ltd., non-ferrous metal specialist, of Nechells, Birmingham, has bought a site consisting of 31 acres at Lea Hall, on the Coventry side of Birmingham. It is intended to make light metal alloys for the aircraft industry at the new works, and the scheme is expected to cost about a million pounds. An appeal is to be made by the Appleby-Frodingham Steel Company, Ltd., to Quarter Sessions against an increase from £29,500 to £45,000 in the rating assessment of its Scunthorpe works. The assessments of the Scunthorpe works of John Lysaght, Ltd., Richard Thomas and Co., Ltd., and Thos. Firth and John Brown, Ltd., have been increased. The Lincolnshire Ironmasters' Association has retained a rating specialist to oppose the higher figures. Wm. Gray and Co., Ltd., West Hartlepool, have secured an order from W. H. Cocker Line and Co., Ltd., for a 9000-ton cargo boat. The Brush Electrical Engineering Company, Ltd., has secured a repeat order from J. and E. Hall, Ltd., of Dartford, for the Blue Line, for four 250 B.H.P. Brush Diesel engines, making twenty in all. The first sixteen have been installed in pairs over a period of four years for driving refrigeration compressors in the new Blue Star motor vessels. The two latest ships will be similarly equipped. It is expected that a contract will be placed in this country for the supply of forty-two locomotives for the Turkish State Railways as a result of the visit to that country of the secretary of the Locomotive Manufacturers' Association. The Great Western Railway Company will shortly place in service in South Wales a tractor driven by producer gas. The Home Office has placed an order for 120,000 tons of sheets for A.R.P. shelters. The transaction was carried out with the Sheetmakers Conference. The Department of Overseas Trade announces that the following contracts are open for tender:—Indian Stores Department: Quantities of forged steel buffer plungers and casings (New Delhi, January 30th); supply and delivery of 1000 steel superheating flues, 5½in. outside diameter by 8 s.w.g. thick by 13ft. 3¼in. length (New Delhi, February 6th). Egyptian Ministry of Communications: Supply and erection of a new swing bridge over the navigable junction of Rayah el Beheira and a culvert over Itai-el-Barud drain (Cairo, February 6th).

Copper and Tin

The copper market this week has been overshadowed by the bad statistics which were published at the end of last week. It was expected that the figures would show a considerable increase in the stocks, but the position disclosed was rather worse than had been anticipated. The world's stocks, including a rise in the blister copper stocks, increased during December by 37,217 tons, compared with those at the end of November. The following are the statistics for December, the totals in brackets relating to the previous month:—Production in the United States 71,795 tons (72,986 tons), elsewhere 122,592 tons (125,642 tons); consumption in the United States 38,853 tons (51,297 tons), elsewhere 118,317 tons (126,687 tons); stocks in the United States at the end of December 289,755 tons (269,488 tons), elsewhere 167,413 tons (155,049 tons); increase in blister stocks, United States 3848 tons, elsewhere 738 tons. It is anticipated that these figures will be the worst for some time as they reflect a period of unrestricted production, and from January onwards the copper producers' curtailment of output scheme should make itself visible in the monthly figures. Nevertheless, for the time being the effect upon the market has been to check industrial buying. There is obviously plenty of copper about and consumers in these conditions are seldom inclined to buy for more than a short time ahead. Government buying has also been quiet, the only purchases of importance having been made by Japan. The American market has been adversely affected by the statistics and there has been renewed talk of drastically reducing the American domestic price of 11·25c. per pound. The standard copper market has been affected by the prevailing conditions, and business has been transacted on a restricted scale. The undertone of the market, however, has remained fairly steady, and after the first shock of the adverse statistics had passed prices developed a rather firmer tone.... Steady conditions have ruled in the tin market, although business has been rather inactive. The control of the market by the International Tin Committee seems to be so complete that neither speculators nor dealers show much initiative. American buying, which, at one time, seemed on the point of developing, has again faded out, and this is regarded as one of the most disappointing features of the position. Supplies coming forward seem to be rather in excess of consumption. Little confidence is felt in the trade situation and industrial buying has been on a hand-to-mouth scale since the beginning of the year.

Lead and Spelter

Prices in the lead market have fluctuated within narrow limits, but considering the number of declarations of lead due to arrive the market has shown more strength than might have been expected. There seems little confidence in the immediate future of the market, and since the Christmas holidays consumers have bought largely on a hand-to-mouth scale. Of the recent heavy arrivals a good proportion was of Empire origin upon which a premium would have to be paid of 7s. 6d. if taken up by dealers, with the result that the metal weighed upon the market and caused a widening of the contango. This was followed by the liquidation of a number of bull engagements. The general impression is that the world's production is still rather in excess of consumption, but, of course, this may be changed in the near future through the operation of the restriction of output scheme which the producers are now putting into force. According to American figures, the world's production during November was 150,600 tons, compared with 155,700 tons in October. In the American market the activity which prevailed until recently has declined, but the price has remained firm. It is expected that the American deliveries to consumers during December will amount to about 33,000 tons, compared with 35,000 tons in the previous month. A certain amount of Empire as well as Mexican lead which arrived recently has been put into warehouse.... After a period of dull trading prices in the spelter market moved sharply upwards at the end of last week. The general impression seemed to be that the buying was the result of galvanisers coming into the market in anticipation of increased requirements to meet orders which it was expected would be received on account of A.R.P. In other directions consumers have not shown much interest, whilst speculation has been decidedly quiet. American figures give the production of spelter in the United States during December as 44,800 tons, against 40,343 tons in November. At the end of the year the stocks in the United States totalled 126,600 tons, against 120,700 tons at the end of November.

Current Prices for Metals and Fuels

Makers' official home trade price, per ton, delivered buyers' stations. *Joists, Sections, Bars and Plates are subject to a rebate of 15s. to home users purchasing only from Associated British Steelmakers. † Export prices are for Empire Markets; for other Markets British quotations conform to Cartel prices.

PIG IRON.

Foundry home prices, except for Scotland, less rebate of 5/–

	Home.	Export.
(D/d Teesside Area.)	£ s. d.	£ s. d.
N.E. COAST—		
Hematite Mixed Nos.	6 0 0	—
„ No. 1	6 0 6	5 15 0
Cleveland—		
No. 1	5 2 0	5 2 6
No. 3 G.M.B.	4 19 0	5 0 0
No. 4 Foundry	4 18 0	—
Basic	4 12 6	—
MIDLANDS—		
Staffs— *(Delivered to Black Country Station.)*		
North Staffs. Foundry	5 1 0	—
„ „ Forge	4 18 0 to £5 0 0	—
Basic	4 12 6	—
Northampton—		
Foundry No. 3	4 18 6	—
Forge	4 15 6 to £4 17 6	—
Derbyshire—		
No. 3 Foundry	5 1 0	—
Forge	4 18 0 to £5 0 0	
SCOTLAND—		
Hematite, f.o.t. furnaces	6 0 6	—
No. 1. Foundry, ditto	5 8 0	—
No. 3 Foundry, ditto	5 5 6	—
Basic, d/d	4 12 6	—
N.W. COAST—	6 0 6 d/d Glasgow	
Hematite Mixed Nos.	6 6 0 „ Sheffield	
	6 12 0 „ Birmingham	

MANUFACTURED IRON.

	Home.	Export.
LANCS. AND YORKS.—	£ s. d.	£ s. d.
Crown Bars	12 5 0	—
Best Bars	12 15 0	—
MIDLANDS—		
Crown Bars	12 5 0	—
Marked Bars (Staffs)	15 15 0	—
No. 3 Quality	10 17 6	—
No. 4 Quality	11 7 6	—
SCOTLAND—		
Crown Bars	12 5 0	12 5 0
Best	12 15 0	12 15 0
N.E. COAST—		
Crown Bars	12 5 0	12 5 0
Best Bars	12 15 0	12 15 0
Double Best Bars	13 5 0	13 5 0
NORTHERN IRELAND AND FREE STATE—		
Crown Bars, f.o.q.	12 17 6	—

STEEL.

	*Home.	†Export.
LONDON AND THE SOUTH—	£ s. d.	£ s. d.
Angles	10 10 6	10 0 0
Tees	11 10 6	11 0 0
Joists	10 10 6	10 0 0
Channels	10 15 6	10 5 0
Rounds, 3in. and up	11 10 6	11 0 0
„ under 3in.	11 17 6‡	11 0 0
Flats, under 5in.	11 17 6‡	11 0 0
Plates, ¼in. (basis)	10 15 6	10 2 6
„ ⅜in.	11 0 6	10 7 6
„ ½in.	11 5 6	10 12 6
„ ⅝in.	11 10 6	10 17 6
Un. ⅝in. to and incl. 6 lb. per sq. ft. (8-G.)	11 12 6	12 10 0
Boiler Plates, ¼in.	11 13 0	11 12 6
NORTH-EAST COAST—	£ s. d.	£ s. d.
Angles	10 8 0	10 0 0
Tees	11 8 0	11 0 0
Joists	10 8 0	10 0 0
Channels	10 13 0	10 5 0
Rounds, 3in. and up	11 8 0	11 0 0
„ under 3in.	11 15 0‡	11 0 0
Plates, ¼in. (basis)	10 10 6	10 2 6
„ ⅜in.	10 15 6	10 7 6
„ ½in.	11 0 6	10 12 6
„ ⅝in.	11 5 6	10 17 6
Un. ⅝in. to and incl. 6 lb. per sq. ft. (8-G.)	11 12 6	12 10 0
Boiler Plates, ¼in.	11 8 0	11 12 6
MIDLANDS, AND LEEDS AND DISTRICT—	£ s. d.	£ s. d.
Angles	10 8 0	10 0 0
Tees	11 8 0	11 0 0
Joists	10 8 0	10 0 0
Channels	10 13 0	10 5 0
Rounds, 3in. and up	11 8 0	11 0 0
„ under 3in.	11 16 0‡	11 0 0
Flats, 5in. and under	11 15 0‡	11 0 0
Plates, ¼in. (basis)	10 13 0	10 2 6
„ ⅜in.	10 18 0	10 7 6
„ ½in.	11 3 0	10 12 6
„ ⅝in.	11 8 0	10 17 6
Un. ⅝in. to and incl. 6 lb. per sq. ft. (8-G.)	11 12 6	12 10 0
Boiler Plates, ¼in.	11 10 6	11 12 6

STEEL (*continued*).

	*Home.	†Export.
GLASGOW AND DISTRICT—	£ s. d.	£ s. d.
Angles	10 8 0	10 0 0
Tees	11 8 0	11 0 0
Joists	10 8 0	10 0 0
Channels	10 13 0	10 5 0
Rounds, 3in. and up	11 8 0	11 0 0
„ under 3in.	11 15 0‡	11 0 0
Flats, 5in. and under	11 15 0‡	11 0 0
Plates, ¼in. (basis)	10 10 6	10 2 6
„ ⅜in.	10 15 6	10 7 6
„ ½in.	11 0 6	10 12 6
„ ⅝in.	11 5 6	10 17 6
Un. ⅝in. to and incl. 6 lb. per sq. ft. (8-G.)	11 12 6	12 10 0
Boiler Plates, ¼in.	11 8 0	11 12 6
SOUTH WALES AREA—	£ s. d.	£ s. d.
Angles	10 8 0	10 0 0
Tees	11 8 0	11 0 0
Joists	10 8 0	10 0 0
Channels	10 13 0	10 5 0
Rounds, 3in. and up	11 8 0	11 0 0
„ under 3in.	11 15 0‡	11 0 0
Flats, 5in. and under	11 15 0‡	11 0 0
Plates, ¼in. (basis)	10 13 0	10 2 6
„ ⅜in.	10 18 0	10 7 6
„ ½in.	11 3 0	10 12 6
„ ⅝in.	11 8 0	10 17 6
Un. ⅝in. to and incl. 6 lb. per sq. ft. (8-G.)	11 12 6	12 10 0

IRELAND—F.O.Q.—	BELFAST. £ s. d.	REST OF IRELAND. £ s. d.
Angles	10 13 0	10 15 6
Tees	11 13 0	11 15 6
Joists	10 13 0	10 15 6
Channels	10 18 0	11 0 6
Rounds, 3in. and up	11 13 0	11 15 6
„ under 3in.	12 0 0‡	12 2 6
Plates, ¼in. (basis)	10 15 6	10 18 0
„ ⅜in.	11 0 6	11 3 0
„ ½in.	10 5 6	11 8 0
„ ⅝in.	11 12 6	12 10 0
Un. ⅝in. to ¼in. incl.	11 12 6	11 12 6

‡ *Rounds and Flats tested quality; untested, 3s. less.*

OTHER STEEL MATERIALS

	Home. £ s. d.	Export, f.o.b. £ s. d.
Sheets—		
11-G. and 12-G., d/d	13 15 0	11-G. to 14-G. 12 10 0
13-G., d/d	14 2 6	
14-G. to 20 G., d/d	14 10 0	15-G. to 20-G. 12 15 0
21-G. to 24-G., d/d	14 15 0	21-G. to 24-G. 13 0 0
25-G. and 26-G., d/d	15 10 0	25 and 26-G. 13 15 0

South Africa, Rhodesia, Nyasaland, £14; Canada, £14 12s. 6d., f.o.b. basis. Irish Free State, £14 15s., f.o.q., 4-ton lots.

The above home trade sheet prices are for 4-ton lots and over; 2-ton to 4-ton lots, 7s. 6d. per ton extra; and under 2-ton lots to 10-cwt., £2 per ton extra.

Galvanised Corrugated Sheets, basis 24-G.—

Home.	£ s. d.
4-ton lots and up	17 5 0
2-ton to 4-ton lots	17 12 6
Under 2 tons	18 17 6

Export: India, £15 15s. c.i.f.; Irish Free State, £17 5s., f.o.q.; General, £15 15s., f.o.b., 24-G. basis.

TIN-PLATES—
20 by 14 basis, f.o.b., Bristol Channel Ports, 20s. 3d.
Tin-plate Bars, d/d Welsh Works, £7 5s.

BILLETS—100-ton lots and over, 35 to 100 tons, 5s. extra; less than 35 tons, 10s. extra.

	£ s. d
Soft (up to 0·25% C.), untested	7 7 6
„ „ tested	7 12 6
Basic (0·33% to 0·41% C.)	7 17 6
„ Medium (0·42 to 0·60% C.)	8 10 0
„ Hard (0·61% to 0·85% C.)	9 0 0
„ „ (0·88% to 0·99% C.)	9 10 0
„ „ (over 0·99% C.)	10 0 0
Rails, Heavy, 500-ton lots, f.o.t.	9 10 0
„ Light, f.o.t.	8 10 0

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	4/9½ per lb. (nominal)	
Ferro-Tungsten	4/8 per lb. (nominal)	
Ferro-Chrome, 4 p.c. to 6 p.c. carbon	£23 15 0	7/6
„ 6 p.c. to 8 p.c.	£23 10 0	7/6
„ 8 p.c. to 10 p.c.	£23 10 0	7/6
„ Max. 2 p.c. carbon	£36 0 0	11/–
„ „ 1 p.c. carbon	£38 5 0	11/–
„ „ 0·5 p.c. carbon	£41 0 0	12/–
„ „ carbon-free	10d. per lb.	
Metallic Chromium	2/5 per lb.	
Ferro Manganese (loose), 76 p.c.	£16 15 0 home	
„ Silicon, 45 p.c. to 50 p.c.	£12 10 0 scale 5/– p.u	
„ „ 75 p.c.	£17 0 0 scale 6/– p.u	
„ Vanadium	14/– per lb.	
„ Molybdenum	4/9 per lb.; 5/– forward	
„ Titanium (carbon-free)	9d. per lb.	
Nickel (per ton)	£185 to £190 per ton	
Cobalt	8/6 to 8/9 per lb.	

NON-FERROUS METALS.

(Official Prices, January 18th.)

COPPER—	
Cash	£43 1 3 to £43 2 6
Three Months	£43 6 3 to £43 7 6
Electrolytic	£48 0 0 to £49 0 0
Best Selected Ingots, d/d Birmingham	£48 15 0
Sheets, Hot Rolled	£80 0 0
	Home. Export.
Tubes, Solid Drawn (basis)	12¾d. 12¾d.
„ Brazed (basis)	12¾d. 12¾d.
BRASS—	
Ingots, 70/30, d/d Birmingham	£38 0 0
	Home. Export.
Tubes, Solid Drawn, 2/1 Alloy	11¼d. 11¼d.
„ Brazed	13¼d. 13¼d.
TIN—	
Cash	£216 7 6 to £216 10 0
Three Months	£217 2 6 to £217 5 0
SPELTER—	
Cash	£13 13 9 to £13 15 0
Three Months	£13 18 9 to £14 0 0
LEAD—	
Cash	£14 10 0 to £14 11 3
Three Months	£14 13 9 to £14 15 0
Aluminium Ingots (British)	£94 (net)

FUELS.

SCOTLAND

	Export.
LANARKSHIRE—	
(f.o.b. Grangemouth)—	
Navigation Unscreened	18/6
Hamilton Ell	18/6
Splints	19/– to 19/6
AYRSHIRE—	
(f.o.b. Ports)—Steam	16/9 to 17/–
FIFESHIRE—	
(f.o.b. Methil or Burntisland)—	
Prime Steam	17/6 to 18/–
Unscreened Navigation	18/– to 18/6
LOTHIANS—	
(f.o.b. Leith)—Hartley Prime	17/6
Secondary Steam	16/9

ENGLAND

SOUTH YORKSHIRE, DONCASTER—	
Steam Hards	19/– to 20/–
Washed Smalls	15/6 to 16/6
NORTHUMBERLAND, NEWCASTLE—	
Blyth Best	18/6
„ Second	17/3
„ Best Small	17/–
Unscreened	17/– to 18/–
DURHAM—	
Best Gas	19/4½
Foundry Coke	27/– to 28/–

SOUTH WALES

CARDIFF—	
Steam Coals:	
Best Admiralty Large	24/–
Best Seconds	23/6 to 24/–
Best Dry Large	23/– to 23/6
Ordinaries	23/–
Bunker Smalls	16/– to 17/6
Cargo Smalls	15/6 to 16/–
Dry Nuts	27/6 to 28/–
Foundry Coke	31/– to 42/6
Furnace Coke	29/–
Patent Fuel	25/6
SWANSEA—	
Anthracite Coals:	
Best Large	38/– to 41/–
Machine-made Cobbles	41/– to 45/6
Nuts	40/– to 45/–
Beans	33/– to 38/6
Peas	26/– to 30/–
Rubbly Culm	15/– to 16/–
Steam Coals:	
Large Ordinary	22/6 to 24/6

FUEL OIL.

Inland consumption: contracts in bulk.

Exclusive of Government tax of 1d. per gallon: and 9d. per gallon on oil for road vehicles.

Ex Ocean Installation.	Per Gallon.
Furnace Oil (0·950 gravity)	3½d.
Diesel Oil	4½d.

French Engineering Notes

(From our own Correspondent in Paris)

The Battleship "Richelieu"

THE 35,000-ton battleship "Richelieu," which was floated at Brest on Tuesday last, January 17th, was laid down in October, 1935, and was followed by the "Jean-Bart" at Saint-Nazaire, as a reply to the two Italian ships of the same tonnage. The building of the "Richelieu" has occupied much more than the normal time in consequence of the short working hours and strike troubles, and the "Jean-Bart" has naturally suffered from the same disabilities, but with the extension of hours now enforced, and a more effective organisation for acceleration of naval construction, it is hoped that the two similar battleships to be put in hand will be completed in record time, so far as this country is concerned. With a powerful artillery and a speed of probably more than 30 knots, the "Richelieu" will be a formidable fighting unit. Her length is 245 m., her width 33 m., and she will draw 8·15 m. of water. There is one funnel behind the heavily protected control tower in the centre, and two axial quadruple turrets are placed forward, one on a higher deck to fire over the other. The eight guns are of 380 mm. Five triple turrets with 152 mm. guns are arranged three abaft in a triangular position and one on each side of the upper deck nearly amidships. On the upper deck there are twelve 100 mm. guns, as well as a quantity of lighter artillery. The battleship will carry four aeroplanes to be launched by catapult. The propelling machinery will consist of four turbines supplied with steam by oil-fired generators. They are to develop at least 150,000 H.P. The ship will carry about sixty officers and a crew of 1500 men. After the floating of the "Richelieu" work will begin on the "Georges-Clemenceau."

Foreign Trade Exchanges

The returns of foreign trade during 1938 offer apparent grounds for satisfaction as to the country's economic welfare. Every possible effort has been made to reduce the unfavourable balance that has grown steadily during the past few years, and as the adverse balance for 1938 fell to 15,395 million francs, or 3057 millions less than in the previous year, the situation is regarded as encouraging. The dislocation of world economics and finance has given more importance to this phase of foreign trade than it had when profits derived from international services more than counterbalanced trade deficits. Nevertheless, such profits, so far as this country is concerned, have fallen considerably and opportunities for a normal expansion of exports are practically negligible. When, therefore, the year's returns show a notable appreciation in values and a diminution of the adverse trade balance, the general impression is favourable. But an analysis of the figures gives less cause for satisfaction. During the first half of 1938 there was a steady depreciation of the franc until the present Government took measures to arrest the decline and prepare for a general economic recovery, which began to take effect towards the end of the year. Since June last the franc has been practically stabilised at its present level. In view of the monetary depreciation, following upon previous devaluations, manufacturers should have had greater facilities for selling goods abroad, but such facilities were neutralised by rising prices and fiscal and labour costs, and by a decline of labour efficiency which is, fortunately, now being restored to the normal. It will thus be seen that a comparison of values in 1938 with those of the previous year is misleading as an indication of industrial activity. Imports were valued at 45,981 million francs, an increase on the year of about 8½ per cent., and exports totalled 30,585 million francs, an increase of nearly 28 per cent. But the tonnage of imports, amounting to 47,155,470 tons, showed a decline of 10,249,950 tons, and exports totalled 26,986,661 tons, or 3,606,883 tons less than in the previous year. The only increases were in the exports of foodstuffs and manufactured goods, the latter totalling 2,712,202 tons, or 6027 tons higher on the year. Efforts are now being concentrated on an expansion of export trade, manufacturers being offered rebates on fiscal charges according to the production for export, and commercial arrangements with countries all over the world have either been modified or are being negotiated with the object of correcting adverse trade balances. In present circumstances, there seems to be no way out of the country's economic difficulties except by bringing exports up to the level of imports, and if this can be done there is so much leeway to be made up by the French that it will mean increased industrial activity for some time to come.

Level Crossings

During the past two years the sum of 260 million francs has been spent on the abolition of level crossings, but as there are many thousands of such crossings the cost of eliminating them all would be far beyond the financial means of the State and the National Railway Company. Since the work began, on what are often really costly undertakings, the expenditure has been extremely heavy. The company can therefore only continue the programme which the old companies had in hand for the elimination of 300 or 400 of the more dangerous crossings. The co-ordination of rail and road transport has helped partially to solve the problem of safety at level crossings on secondary railways where a few trains are left for the carriage of goods and most of the passengers are transported by road. A formula is now employed for determining the conditions under which cars may traverse such level crossings without its being necessary to have men constantly on duty to close and reopen gates at very long intervals. The formula takes as factors the number of trains and cars running in twenty-four hours and their respective speeds, as well as the visibility. Obstructions to visibility between trains and cars at the specified distances for safe crossing must be removed. Between 2000 and 3000 level crossings will be left open, and a notable economy will be effected in the railway service. It is curious to find the system based on a formula, although luminous and sound signals will doubtlessly be used to announce the approach of occasional trains.

British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

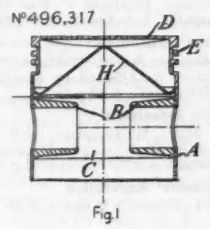
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES

496,317. October 5th, 1937.—IMPROVEMENTS IN PISTONS, Arthur Villeneuve Nicolle and the Automotive Engineering Company, Ltd., both of 104, The Green, Twickenham, Middlesex.

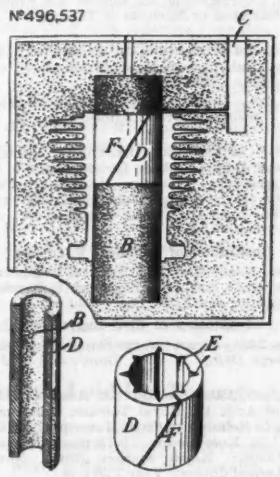
The invention consists of a piston, the skirt of which is of thin steel wherein, in order adequately to protect the thin piston against overheating, the interior of the piston is formed with a chamber adapted to contain a cooling medium, such as a readily fusible salt or metal, while the skirt of the piston in the region of the gudgeon pin bosses is either thickened or the bosses are formed in a ring which is secured to the thin skirt. Fig. 1 is a section of one piston construction in accordance with the invention, and Fig. 2 is a section of an alternative construction. The piston has a thin steel skirt A and in order that



the forces exerted upon the gudgeon pin bosses B may be transmitted to the skirt satisfactorily the bosses are formed integrally with the ring C which is secured to A. The crown D may be integral with the skirt, as shown, or may be separately formed and secured to it. In the modification illustrated in Fig. 2, the crown D of the piston is integral with the head portion E and the skirt A is separately formed and provided with a thickened ring F in the region of the gudgeon pin bosses B, which are separately formed and provided with arcuate extensions for attachment to the inner surface of the ring. For effective cooling, the interior may be formed with a chamber G, between the interior surfaces of the head part E, the crown D and an insert or lining H.—*November 29th*, 1938.

496,537. May 13th, 1938.—IMPROVED METHOD OF CASTING ENGINE CYLINDERS, The Birco Motor Cylinder Company, Ltd., Oak Road, West Bromwich, Stafford, and Jack Pearson Howell, of the company's address.

This invention relates to an improved method of casting engine and like cylinders, and it has for its chief object to enable the production of a cylinder whose bore is substantially free from distortion under normal working conditions and whose working surface has a high resistance to wear. A sand mould of suitable composition is used and is divided horizontally into two parts, of which the lower is shown. The moulding sand is packed around a pattern which is then removed and replaced by a hollow sand core B of cylindrical form. The extremities of this core are accommodated in semi-cylindrical recesses produced in the mould by the ends of the pattern. One end of the moulding cavity between the mould and the core communicates by a transverse passage with a filling gate C. Surrounding and embedded in the sand core is a complete cast iron or other metal sleeve D (termed the "densener"), the exterior surface of which is flush with that of the core. This densener is rammed up with the sand during the production

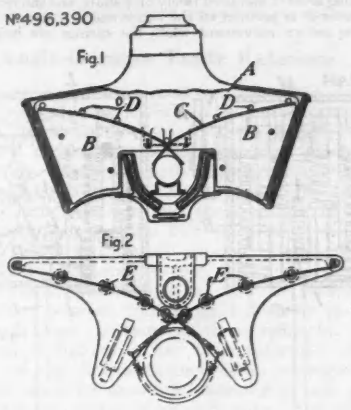


of the core, and may be regarded as part thereof. In the construction shown, the length of the densener and its position in relation to the moulding cavity is such that the portion of the cylinder wall cast in contact therewith extends from the level of the top piston ring at top dead centre of the engine crankshaft to the level of the top (or bottom) piston ring at bottom dead centre. Internally, D is formed with longitudinal grooves E of vee or other section, which extend the full length, and a slot F extending from end to end. The composite core is inserted into the mould with the densener D in a cold state so that the cast metal coming into contact with the densener is cooled at a much greater rate than the metal in contact with the sand portion of the core. It is pointed out that the cooling of such metal is not accelerated sufficiently for a chilled iron casting to be produced. D is designed so that its effect is to produce in the casting a toughened section having a very fine graphitic structure. The inherent flexibility of D owing to the grooves E and slot F (causes it to yield inwards during the contraction of the casting around it. In the lower portion of the cylinder casting, contraction stresses are relieved by the hollow core collapsing inwardly. The normal width of the slot F is a matter of importance, and should be such as to allow full contraction of the casting at its thickest section.—*December 1st*, 1938.

LIGHTING AND HEATING

496,390. May 29th, 1937.—IMPROVEMENTS IN LIGHTING FITTINGS, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2; Robert Maxted, 161, Clifton Road, and Edward Browne Tuppen, 54, Hillmorton Road, Rugby.

The present invention is concerned with improvements relating to lighting fittings of that type comprising a casing for supporting a light source, such as, for example, an elongated mercury or sodium vapour discharge lamp above which a reflector, curved in one plane only, is arranged for reflecting out of the casing rays of light directed upwardly from the light source. Its main objects are to provide an arrangement whereby the reflector may be readily and correctly positioned without the exercise of any great skill, and whereby the reflector, if it is only formed approximately to shape, will be correctly shaped when inserted into position in the fitting. The general arrangement of the fitting can be clearly seen from the drawing. It includes a pair of castings A at either end of the fitting. The lighting fitting has a pair of side reflectors B and a main upper reflector C. The reflectors B are held in the fitting

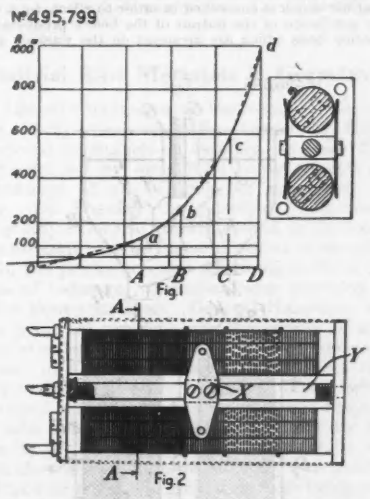


by means of dowel screws passing into the castings, and the holes in the casting are correctly located by means of jig drilling. The reflectors B are flat and aid in supporting C. Further screws D are used to lie against the upper surface of C, and cause it to occupy a predetermined position. Moreover, C need only be formed approximately to shape as when it is located against the screws D they will serve to hold the reflector to maintain its correct profile. In the embodiment shown in Fig. 2, the screws or studs D are replaced by studs E in drilled holes in the end castings A, and their inner ends are slotted to receive the end of the reflector C. The studs E are preferably formed with reduced ends which pass through the holes in the casting and are lightly riveted over washers on the outer side of the casting to hold them in place while permitting them to be turned to bring the slots into position to receive the end of the reflector. In the drawing accompanying the present specification C is provided with a bent-over edge to engage loosely a tie rod which extends between the two end castings A of the casing. This arrangement enables the reflector to be loosely supported while its end is fitted in the slots in the studs when assembling the fitting.—*November 29th*, 1938.

MISCELLANEOUS

495,799. May 21st, 1937.—VARIABLE ELECTRIC RESISTANCES, Standard Telephones and Cables, Ltd., and William Herbert Morgan Hellner, both of Connaught House, 63, Aldwych, London, W.C.2.

This invention relates to variable resistance elements such as potentiometers, and has for its object to produce a resistance element in which the amount of displacement of the contact member is a logarithmic function of the resistance of the wire between one terminal of the wire and the moving contact. The insulation is removed from the wire wound on formers, shown in Fig. 2, along the track of the contact studs. The block X may be traversed along the resistance wire by turning the rod Y. Each of the windings on the formers consists of successive lengths of wire giving the respective

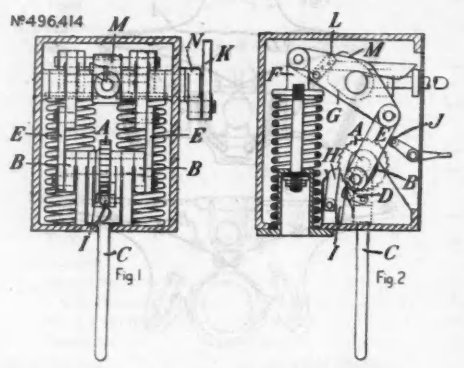


resistance curves O A, A B, B C, and C D of Fig. 1. A description of the winding on one former applies also to that on the other former. The portion O A indicated on the curve is wound with constantan wire 37 S.W.G., the portion A B with constantan wire of 40 S.W.G., the portion B C with wire of 40 S.W.G., and the portion C D with wire of 43 S.W.G., both the latter being of "Nichrome." The first portion of 37 S.W.G. is enamelled, whilst the second portion of 40 S.W.G. constantan wire is double-silk covered. This difference in the thickness of the insulation covering the two different wires spaces the wire of thinner gauge from the former on which it is wound to a greater extent than the surface of the thicker wire, so that the difference of level along the path along which the insulation is removed is only about 0·001in. The next section of 40 S.W.G Nichrome wire is enamelled, as the difference in its distance from the former as compared with the wire of 40 S.W.G.,

double silk covered, is less than the difference of thickness between wires of adjacent gauges. The wire of 43 S.W.G. is again double silk covered, which reduces the difference in height from the wire of 40 S.W.G. along the path of the slider to 0·0002in. The winding is covered with shellac to hold it in position on the former and to prevent any fraying of the silk insulation covering when the wire is bared along the paths of the slider.—*November 21st*, 1938.

496,414. June 30th, 1937.—SPRING MECHANISM, The English Electric Company, Ltd., Queen's House, 28, Kingsway, London, W.C.2, and William Leslie Johnson, "Windy-Brae," Olderoft Road, Walton, Staffordshire.

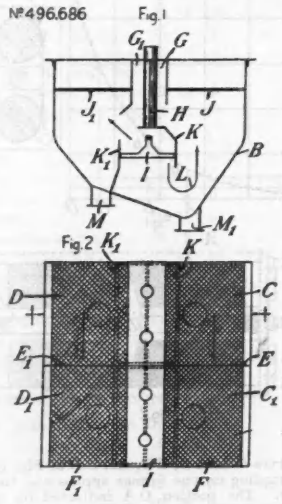
This invention relates to a device of the type in which energy can be stored by stressing a spring and then released to perform the closing operation of electrical switchgear of a type which is too heavy to be closed sufficiently rapidly by direct manual operation. Referring to the drawings, a ratchet wheel A can turn solidly with a pair of cranks B. A long hand lever C turning freely on the crankshaft and carrying a pawl D pressed into engagement with A by a spring rotates A and the cranks B step by step. The connecting-rods E pivoted to the cranks B are adapted, on rotation of the cranks, to reciprocate members F to compress the springs. Each rod E is pivoted to one end of a rocking lever G mounted freely on a shaft, and the reciprocating member F is pivoted to the other end. A detent H locks A against return movement while the springs are being com-



pressed. The arrangement is such that normally each crank B and connecting-rod E are in the dead centre position as shown in Fig. 2 with the springs extended. Rotation of the cranks by means of C through 180 deg. to the other dead centre position fully stresses the springs. It is usually desirable to be able to wind up the device and leave it charged until wanted for use. To meet this condition one of the cranks, or, as shown, a member I, carried round with them and projecting from the ratchet wheel A, is adapted to be obstructed, after rather more than 180 deg. of movement (*i.e.*, after passing the dead centre), by a removable abutment comprising a roller J on the end of a trigger lever. The device can be left in this condition until required for use when it is released by moving the trigger. The drive from the device to the arm K of the switch-operating mechanism is transmitted by means of a pawl L mounted on a pivot pin carried between the rocking levers G. This pawl L engages a projecting part of a crank M fixed to the shaft, which also has fixed thereto a second crank N to which the switch-operating arm K is connected.—*November 30th*, 1938.

496,686. June 28th, 1937.—SCREENING COAL OR SIMILAR PRODUCTS, Automatic Coal Cleaning Company, Ltd., 11, New Court, Carey Street, Lincoln's Inn, London, W.C.2.

The apparatus comprises a trough B of sheet steel divided into compartments C and C_1 on one side, arranged in series, and compartments D and D_1 on the other. The crude coal is introduced at the head of the compartments C and D. It travels in the direction of the arrows and passes over sills E and E_1 between the compartments. Schist is extracted across the filtering bed of the compartments C and D. Mixed products are extracted across the filtering bed of the compartments C_1 and D_1, and above the sills F and F_1, in which the compartments C_1 and D_1 end, washed coal is obtained. In Fig. 1, which is a section through the centre of the compartments C and D, is shown how the screening device is constructed. In the interior of the trough B are two air chambers G and G_1, which do not communicate with one another owing to a central partition H which separates the two compartments C and D from one another, and which occupies the whole length of each of them. At the upper part of each of the two chambers G, G_1, there is a flow of air which is controlled in order to effect, by a known process, regulation of the output of the heavy products across the filtering beds which are arranged on the washing grids J



and J_1. Two metal sheets K and K_1 extend from one end to the other of the side plates of the trough B. These sheets have two vertical portions between which is arranged, for each group of grids, a piston I secured to the ends of piston-rods, passing through tubes welded to the sheets of the air chambers through which they pass. Each piston is thus connected to a mechanical device which actuates it. In operation, when the piston I moves upwardly, it forces the water towards the grid J_1 and the chamber G_1, while the level of water which is beneath the grid J sinks. When the piston moves downwards it forces the water, as shown by the arrow L, towards the grid J and the chamber G, while the level of water which is beneath the grid J_1 sinks. As shown by the drawings, the sheets K and K_1, in conjunction with the shaped outer wall of the air chamber G_1, prevent the products which have passed through the grids and are falling towards the bottom of the trough B from meeting the piston during their fall. The drawings show a screening device comprising two groups of washing grids which are arranged in series, but the invention covers a screening device comprising any number of such groups in series. The number of groups will be selected in accordance with the products to be purified. The products having traversed the filtering bed situated on the grid J_1 are evacuated by a suitable system of piping M, and the products which have traversed the filtering bed situated on the grid J are evacuated by a suitable system of piping M_1.—*December 5th*, 1938.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Bradford Engineering Society

Monday, Jan. 23rd.—Technical College, Bradford. "Fuel Oil for Heating and Hot Water Supply," I. Lubbock. 7.30 p.m.

Chartered Surveyors' Institution

Monday, Feb. 6th.—12, Great George Street, Westminster, S.W.1. "Problems of Valuation as Affected by Modern Legislation," Colonel F. S. Hammond. 6.30 p.m.

Diesel Engine Users Association

Wednesday, Feb. 8th.—Caxton Hall, Westminster, S.W.1. "The Design and Construction of Alternators for Coupling to Diesel Engines," W. R. Holland and F. Fitchett. 5 p.m.

Faraday House Old Students' Association

Friday, Feb. 3rd.—Thames House Restaurant, Millbank, S.W.1. Annual dance. 8 p.m.

Hull Chemical and Engineering Society

Tuesday, Jan. 31st.—Room 51, Municipal Technical College, Park Street, Hull. "Steam Trawlers," A. Addy. 7.45 p.m.

Institute of Fuel

Tuesday, Jan. 24th.—Geological Society's Rooms, Burlington House, Piccadilly, W.1. "The Use of Anthracite Duff for Steam Generation," E. B. Johnson. 6 p.m.

Tuesday, Feb. 7th.—N.W. SECTION: The Engineers' Club, Albert Square, Manchester. "Pitch as a Fuel," R. B. Robinson. 7 p.m.

Thursday, Feb. 9th.—Geological Society's Rooms, Burlington House, Piccadilly, W.1. "The Aerodynamics of the Domestic Open Fire-place," P. O. Rosin. 6 p.m.

Institution of Automobile Engineers

Saturday, Jan 21st.—LONDON GRADUATES: Visit to I.A.E. Research Laboratories, Great West Road, Brentford. 2.30 p.m.

Monday, Jan. 23rd.—GLASGOW CENTRE: 39, Elmbank Crescent, Glasgow. "Factory Experimental Work," A. G. Booth. 7.45 p.m.

Tuesday, Jan. 24th.—BIRMINGHAM CENTRE: James Watt Memorial Inst., Great Charles Street, Birmingham. "Battery-driven Electric Vehicles," R. Tubb. 7.30 p.m.

Friday, Jan. 27th.—GLASGOW GRADUATES: 39, Elmbank Crescent, Glasgow. "Recent Developments in Fuel Injection Equipment," S. R. Williams. 7.45 p.m.

Saturday, Jan. 28th.—BIRMINGHAM CENTRE: Midland Hotel, Birmingham. Dinner and dance. 6 p.m.

Monday, Jan. 30th.—BIRMINGHAM GRADUATES: James Watt Memorial Inst., Great Charles Street, Birmingham. "Modern Automobile Electrical Equipment," E. Scott. 7.30 p.m.

Tuesday, Jan. 31st.—COVENTRY GRADUATES: Broadgate Café, Coventry. "Preparing an Engine for Production, with Special Reference to Methods of Testing," W. H. Wanley. 7.30 p.m.

Thursday, Feb. 2nd.—BIRMINGHAM GRADUATES: Austin Motor Company, Ltd., Longbridge, Birmingham. Address by B. G. Robbins. 7.30 p.m.

Tuesday, Feb. 7th.—Royal Society of Arts, John Street, Adelphi, W.C.2. "Sleeve Valve Engines," A. H. R. Fedden. 7.45 p.m.

Wednesday, Feb. 8th.—DERBY GRADUATES: Technical College, Green Lane, Derby. "Ride Developments of Motor Cars," A. F. Martindale. 7.30 p.m. LIVERPOOL CENTRE: The University (Engineering Department), Liverpool. "The Modern Car from the Owner-driver's Point of View," G. Smith. 7 p.m.

Institution of Chemical Engineers

Thursday, Jan. 26th.—Inst. of Structural Engineers, 11, Upper Belgrave Street, S.W.1. "Floors for Industrial Purposes," R. Fitzmaurice and F. M. Lea. 6.30 p.m.

Institution of Civil Engineers

Tuesday, Jan. 24th.—Great George Street, Westminster, S.W.1. "The Gorge Dam," W. J. E. Binnie and H. J. F. Gourley. 6 p.m.

Wednesday, Jan. 25th.—EDINBURGH ASSOC.: Royal Scottish Society of Arts, 16, Royal Terrace, Edinburgh. "Town Planning in Relation to Civil, Municipal, and County Engineering," D. Ross Young. 6.15 p.m. NEWCASTLE-UPON-TYNE ASSOC.: Royal Station Hotel, Newcastle-upon-Tyne. Annual dinner. 7 for 7.30 p.m.

Thursday, Jan. 26th.—YORKSHIRE ASSOC.: Grand Hotel, Sheffield. Annual dinner. 6.30 for 7 p.m.

Monday, Jan. 30th.—N. IRELAND ASSOC.: Queen's University, Belfast. "Cork Swimming Pool," S. W. Farrington. 6.15 p.m.

Wednesday, Feb. 1st.—MANCHESTER ASSOC.: Midland Hotel, Manchester. Annual dinner. 6.30 for 7 p.m.

Thursday, Feb. 2nd.—PORTSMOUTH ASSOC.: Municipal College, Portsmouth. "The Lymington and Yarmouth Slipways," J. Caesar. 7.15 p.m. YORKSHIRE ASSOC.: Hotel Metropole, Leeds. "Aeroplane Controls and Auxiliaries," G. C. F. Ely. 7.30 p.m.

Institution of Electrical Engineers

Tuesday, Jan. 24th.—SCOTTISH CENTRE: North British Station Hotel, Edinburgh. "Electricity in Coal Mines: A Retrospect and a Forecast," R. Nelson. 7 p.m.

Institution of Heating and Ventilating Engineers

Wednesday, Feb. 8th.—Inst. of Mechanical Engineers, Storey's Gate, Westminster, S.W.1. "The Use of Thermo-couples for Temperature Measurement," Dr. Margaret Fishenden. 2.30 p.m. Park Lane Hotel, Park Lane, W.1. 6.30 for 7 p.m.

Institution of Locomotive Engineers

Wednesday, Jan. 25th.—Inst. of Mechanical Engineers, Storey's Gate, Westminster, S.W.1. "A Diesel Train Set with Multiple Axle Drives," H. F. Haworth and T. Hornbuckle. 6 p.m.

Institution of Mechanical Engineers

To-day, Jan. 20th.—Storey's Gate, Westminster, S.W.1. Papers on "Machine Tool Practice." 6 p.m.

Monday, Jan. 23rd.—LONDON GRADUATES: Storey's Gate, Westminster, S.W.1. "Corrosion," K. Heywood. 6.45 p.m.

Thursday, Jan. 26th.—E. MIDLANDS BRANCH: Technical College, Lincoln. "Precision Measurements as Applied to Engineering Practice," K. E. Summers. 7.15 p.m. N.W. BRANCH: Engineers' Club, Albert Square, Manchester. "Rubber Machinery and Process Plant," E. Morris. 7.15 p.m.

Friday, Jan. 27th.—STEAM GROUP: Storey's Gate, Westminster, S.W.1. "High-lift Safety Valves," G. Sewell. 6 p.m.

Friday, Feb. 3rd.—INTERNAL COMBUSTION ENGINE GROUP: "Concerning Cylinder Bore Wear," A. Taub. 6 p.m.

Institution of Structural Engineers

To-day, Jan. 20th.—MIDLAND COUNTIES BRANCH: James Watt Memorial Inst., Great Charles Street, Birmingham. "Canal Bridges: Notes of Tests on Brick Arches and Reconstruction Schemes," W. M. Veal. 6.30 p.m.

Monday, Jan. 23rd.—JUNIOR SECTION (LONDON): Architectural Assoc., 34–35, Bedford Square, W.C.1. "The Trend of Increasing Legislation Hampers Building," C. Lovett Gill. 7 p.m.

Thursday, Jan. 26th.—11, Upper Belgrave Street, S.W.1. "Floors for Industrial Purposes," R. Fitzmaurice and F. M. Lea. 6.30 p.m.

Junior Institution of Engineers

To-day, Jan. 20th.—39, Victoria Street, S.W.1. "Television," H. J. Shaw. 7.30 p.m.

Friday, Jan. 27th.—39, Victoria Street, S.W.1. "The Isolation of Vibration and Noise from Engineering Plant and Equipment," H. C. Green. 7.30 p.m.

Keighley Association of Engineers

Thursday, Jan. 26th.—Victoria Hotel, Keighley. "The Production, Strength, and Application of the New Alloy Cast Irons," H. A. MacColl. 7.30 p.m.

North-East Coast Institution of Engineers and Shipbuilders

To-day, Jan. 20th.—Mining Inst., Newcastle-upon-Tyne. "Intercrystalline Cracking in Boiler Plates," C. H. Desch. 6 p.m.

Monday, Jan. 23rd.—SUNDERLAND BRANCH: Technical College, Sunderland. "Electric Propulsion of Ships," L. R. Horne. 7.15 p.m.

Wednesday, Jan. 25th.—GRADUATE SECTION: Bolbec Hall, Newcastle-upon-Tyne. "Ships' Life Saving Gear," T. Corin. 7.15 p.m.

North of England Institute of Mining and Mechanical Engineers

Friday, Feb. 3rd.—Old Assembly Rooms, Westgate Road, Newcastle-upon-Tyne. Annual dinner. 7.30 p.m.

Railway Club

Thursday, Feb. 16th.—Royal Scottish Corporation Hall, Fetter Lane, E.C.4. "More About Railways-in-Law," K. Brown. 7.30 p.m.

Royal Aeronautical Society

Tuesday, Feb. 7th.—Inst. of Mechanical Engineers, Storey's Gate, Westminster, S.W.1. "Sleeve Valve Engines," A. H. R. Fedden. 6.30 p.m.

Royal Institution of Great Britain

Saturday, Jan. 21st.—21, Albemarle Street, W.1. "Art and Industry," Lord Gorell. 3 p.m.

Tuesday, Jan. 24th.—21, Albemarle Street, W.1. "Chemical Mechanics," M. Polyani. 5.15 p.m.

Saturday, Jan. 28th.—21, Albemarle Street, W.1. "Art and Industry," F. Pick. 3 p.m.

Royal Society of Arts

Wednesday, Jan. 25th.—John Street, Adelphi, W.C.2. "Trade Associations," W. Tudor Davies. 8.15 p.m.

Wednesday, Feb. 1st.—John Street, Adelphi, W.C.2. "The Difficulties of Air Raid Risks Insurance," P. H. Edwards. 8.15 p.m.

Wednesday, Feb. 8th.—John Street, Adelphi, W.C.2. "Gliding and Soaring," R. Kronfeld. 8.15 p.m.

Rugby Engineering Society

Friday, Feb. 3rd.—Conservative Assembly Room, Albert Buildings, Rugby. "Instructional Films," D. S. Morfey. 7.30 p.m.

Sheffield Metallurgical Association

Tuesday, Jan. 24th.—198, West Street, Sheffield. "The Breakdown of Solid Solutions," C. Sykes. 7.30 p.m.

Stephenson Locomotive Society

Saturday, Jan. 21st.—Y.M.C.A., Blackett Street, Newcastle-upon-Tyne. "The L.M.S. Carlisle–Settle Line," N. Wilkinson. 6.30 p.m.

Monday, Jan. 23rd.—Royal Technical College, Glasgow. "The Railways of Ireland," J. F. McEwan. 7.30 p.m.

West of Scotland Iron and Steel Institute

To-day, Jan. 20th.—Room 24, Royal Technical College, George Street, Glasgow. "Recent Developments in Basic Refractories," J. H. Chesters. 7.15 p.m.

Wolverhampton Engineering Society

Monday, Feb. 6th.—Victoria Hotel, Wolverhampton. "Heavy Machine Tools and Design," J. H. Rivers. 7.30 p.m.

PERSONAL AND BUSINESS ANNOUNCEMENTS

SPANNER THIMBLE TUBE BOILERS, Ltd., has changed its name to Spanner Boilers, Ltd.

DAVID BROWN AND SONS (HUDD.), Ltd., Huddersfield, have opened a branch office at Lloyd's Bank Chambers, Albert Road, Middlesbrough. Mr. A. Richardson will continue to represent the company in the district.

MR. G. H. NISBETT has been elected deputy chairman of the board of directors of British Insulated Cables, Ltd., in addition to retaining his position as managing director. Mr. T. A. Eades, managing director of Automatic Telephone and Electric Company, Ltd., has been appointed a director of the company.

THE NORTH-EASTERN ELECTRIC SUPPLY COMPANY, Ltd., has appointed Lt.-Col. S. E. Monkhouse, M.I.E.E., managing director of the company, and Mr. E. H. E. Woodward, M.I.E.E., general manager. Lt.-Col. Monkhouse joined the company in 1904 and became general manager in April, 1937. Mr. Woodward joined the company in 1909 and has been deputy general manager since April, 1937.